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MEMORANDUM FOR: SD&DS Members

SUBJECT: Final Report Study of COINS Experiment

Attached for your information and retention is a copy of the Final Report, Study of COINS "Experiment" from October 1969 - March 1970. This was prepared by

[redacted] for the COINS

Project Manager.

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[redacted] Chairman

Attachment:

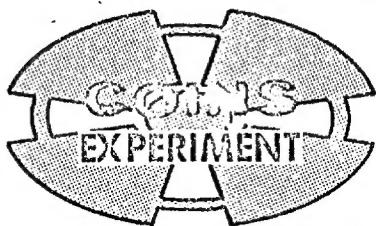
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FINAL REPORT
STUDY OF COINS "EXPERIMENT" (U)

October 1969 - March 1970

TR-70-1169-02

27 March 1970

Prepared for:

National Security Agency

Fort George G. Meade, Maryland 20755

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SECTION 1

SUMMARY OF WORK PERFORMED (U)

(U) During the six months of this contractual effort, the Study Team has worked on eight different aspects of the COINS Experiment. Each of these studies is summarized in this section in accordance with the instructions contained in paragraph 1b of the contractual Data Item Description which states:

"b. Brief summary of all work done, including that yielding negative results or positive results not used. All information shall be referenced to the appropriate Progress Report, or section of the Final Report, where the subject is discussed in detail."

(U) Sections 2, 3 and 4 of this report contain detailed discussions of the work undertaken since the publication of the mid-contract report.

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1.1 ORIENTATION (U)

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(C) Shortly after Informatics was awarded the contract to study the communications subsystem in the COINS "experiment", it was briefed at each of the agencies participating in the experiment.

The first briefing was on the total system [redacted] at NSA. 25X9

Next, half-day briefings at DIA, CIA, NPIC and finally at NSA were given. Since the system was in an experimental stage, most of the information given at these briefings was in terms of current organization of the system, and current operational problems. It became apparent that although the communications software interface had been pre-specified, most agencies were modifying or interpreting communications requirements in light of their own needs. Most of the information presented in the preliminary report was gathered at these orientation meetings. These were a good source of information pertaining to COINS particularly in the area of current operational doctrine.

(U) Since the time of these orientation meetings, each system in the network has undergone some modification. Informatics has kept abreast of these changes by attending the monthly meetings of the Computer Communications Interface Panel (CCIP). It has also attended meetings of the Test and Analysis Panel. Demonstrations have been given using the system at three of the four participating agencies.

(U) These meetings were documented in meeting reports numbered from 1 thru 13.

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1.2 PRELIMINARY RECOMMENDATIONS (U)

(C) The Study Team reviewed the material collected during the orientation task and concluded that there were areas where improvements could be achieved with relatively small investments in resources. These short-term improvements were detailed in Section 3 of the mid-contract report. These recommendations were titled:

1. COMMUNICATIONS HARDWARE PROBLEMS
2. ADD CAPABILITY TO RECOVER FROM SWITCH DISK FAILURE
3. MODIFY FREQUENCY OF SRVC (CHECK OPERATION)
4. MODIFY THE SEGMENTING ALGORITHM
5. IMPROVE LOGGA FILE DATA
6. STANDARDIZE PARITY CHECKING
7. STANDARDIZE PRECEDENCE ALGORITHM
8. STANDARDIZE USE OF ABRT (FAULT)
9. STANDARDIZE TIME OF CLOCKS AT ALL COMPUTERS
10. STANDARDIZE RLSE MESSAGE PROCESSING
11. IMPLEMENTATION OF WARM START CAPABILITY AT NPIC

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1.3 SWITCH CHANGE STUDY (U)

(U) During the data collection phase of the contract, it became apparent that the central switch was not performing all of the functions required by the participating agencies. The switch was losing messages after they had been received for. It was generating more traffic than necessary for the operation of the system through the SRVC (Check) message. And, it was fairly inflexible because of limited core space. Two approaches were examined regarding a change to the communications switch. These were:

1. elimination of the switch,
2. and upgrading of the switch.

Informatics could not then, and cannot now, recommend either course of action. Each has advantages and disadvantages. These have been documented both in the preliminary report and in this final report. Further study in this area will be required to determine what course of action should be followed regarding the COINS communications switch.

(U) This study was documented in Section 2 of the mid-contract report.

1.4 SERVICE CHECK STUDY (U)

(U) During the past few months, Informatics personnel and Computer Communications Interface Panel (CCIP) members have devoted time to the solution of problems caused by current procedure for handling of the SRVC (CHECK) message. Problems occur when participating systems do not receipt SRVC (CHECK) messages in a timely manner. Non-receipt of a CHECK message may indicate any of the following situations:

1. System failure
2. Communication line problems
3. A participating system was unable to generate a RCPT within the time constraints of the switch because of other processing requirements.

If a RCPT is not received for a SRVC (CHECK), the Switch automatically puts the particular system in BREAK status. This is, of course, undesirable if there really aren't system or communications problems. The problem has been recognized by the CCIP members and some general accord has been reached as to solutions. In general, what is required is:

1. modification of the criteria for generating SRVC (CHECK) messages at the switch,
2. an expedient receipting for CHECK messages by the participating systems and,
3. implementation of procedures for determining which line is down when communications problems do occur.

(U) A definitive statement of the problem and its solutions is contained in Section 2.5.5 of this report.

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1.5 COMMUNICATIONS CONTROLLER STUDY (U)

(C) During the data gathering phase of the contract, it was stated by personnel at the CIA that they were receiving unwanted DLE characters in the data stream. Normally the IBM 2701 Communications Controller strips these characters from the data stream. However, the IBM 2701 used by the CIA had been modified to work with synchronous data communications. There were two questions that had to be answered regarding this situation. These were:

1. Why were the DLE characters appearing on the line?
2. Why weren't the other agencies receiving unwanted DLE characters?

(U) Informatics researched the subject through the IBM publications and determined that the reason that DLE characters were appearing on the line was that the IBM 2703 Transmission Control Unit generates DLE/SYN characters whenever the computer fails to service the transmission control unit in timely manner. The reason that the IBM 360/30 computer is unable to service the IBM 2703 transmission control unit in a timely manner is that the computer itself is very slow and there is a model 1850 Channel to Channel Adapter which is attached to the selector channel. The selector channel has priority over the multiplexor channel and therefore uses all of the computer's I/O bandwidth when it is operating. This in addition to the amount of time required for a Start I/O instruction and some of the other character oriented instructions could cause the computer to miss servicing the IBM 2703. Normally the IBM 2701 eliminates DLE/SYN characters, however, the IBM 2701 used in the COINS network has been modified so that only the SYN characters are deleted.

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(U) The reason that the other agencies are not detecting unwanted DLE/SYN characters is that these characters are deleted before they ever appear in a message buffer. The communications data being transmitted to the Univac 494 computers is read into a primary buffer. The data in the primary buffer is transferred on a character by character basis to a message buffer. Each character in the primary buffer is examined and if it is a DLE or an SYN character it is deleted before it is placed in the message buffer.

(U) This study is documented in Section 3.1 of the mid-contract report.

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1.6 MESSAGE DESIGN STUDY (U)

(U) A study of the various message types used in the system and the procedures followed for handling these messages by the various systems in the network has revealed a few inconsistencies and problems. The serious problems have been recognized by the CCIP members and are being resolved. While most of the inconsistencies in interpretation and handling of the various message types do not cause serious problems during the experimental phase, awareness of these inconsistencies should yield a clearer understanding of the performance of the network. An attempt should be made to eliminate them should the network become fully operational.

(U) Section 2 of this report contains definitions of the messages as they now stand, a statement of recognized inconsistencies and problem areas and solutions where applicable. Participants are encouraged to make known any other inconsistencies in interpretation and processing of the various message types as an aid to understanding current performance of COINS. This information will be useful in adding additional systems to the network.

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1.7 DATA COLLECTION STUDY (U)

(U) The Data Collection Study was an outgrowth of the Study Team's attempt to determine the network's quality and reliability. It was necessary to understand the data gathering and analysis methods currently being used to summarize COINS utilization and effectiveness. The results of this study and analysis are detailed in Section 3 of this report.

(U) It should be noted that the COINS system has really been in a "shakedown cruise" state since the inception of its use. Therefore, the data that has been gathered and analyzed thus far reflect equipment changes, software changes, file maintenance changes, and a growing knowledge of the details of COINS design.

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1.8 COMMUNICATIONS STUDY (U)

(U) In the mid-contract report, Informatics investigated the possibility of either upgrading or deleting the 360/30 message switching computer from the COINS network. No recommendations concerning the desirability of either approach were made. It is a very difficult area since any approach one takes has advantages as well as disadvantages. Informatics can still make no recommendation concerning the practicality of keeping the 360/30 switch. In this report certain aspects of this problem have once again been examined. Primarily this effort has been directed to obtaining information about pulse code modulation (PCM) systems. A great deal of time has been spent in researching the T1 system and to outlining areas for future study.

(U) The results of this study are documented in Section 4 of this report.

SECTION 2

MESSAGE DESIGN STUDY (U)

(U) The Study Team was requested to study the COINS messages to determine whether they are effectively performing a necessary function. This section contains the results of that investigation.

(U) One authority on communications indicated that the following types of information must be included in a system where messages are being transmitted from one location to another:

- 1) The message itself (interrogations and answers for COINS)
- 2) Acknowledgement receipt of message containing results of checks for transmission errors.
- 3) Requests for retransmission
- 4) Communications lines' status
- 5) System recovery
- 6) Message status and accountability
- 7) Communications line control characters (such as synchronization, start of message and end of message characters)
- 8) Header information to identify message identifier, originator (device and station), addressee, type of message, and priority

(U) The COINS Network and its message structure has all of these types of information. For the most part, they are organized by message type and controlled and monitored with the assistance of queues. The use of the various message types adequately support the COINS functions defined in COINS Principles of Operations. However, some problems have occurred due to procedures used in handling the various types of messages under some operational

conditions. As was stated in earlier studies, most of the inconsistencies in handling and interpretation of the various message types do not cause serious network problems. If unrecognized, however, these could cause difficulty in evaluation of network performance. If the system is to become fully operational, participating systems should conform as nearly as possible in their processing and use of the message types. New systems joining the network should also conform to the same standard set of definitions. It should be noted that new types of messages can be added to these standards and that definitions of existing types can be changed when these changes constitute an improvement and when the participants consent to conform in their use and interpretation.

(U) Table 2-1 lists the various message-types used by the COINS community. The column on the left identifies the type of information listed above that the message conveys. The two columns on the right indicate the roles that the switch and the participating system have in the use of these messages. The last two types of information (header and communications control characters) are included in every message type and therefore have been omitted from the table.

(U) The discussion of this section has been divided into seven sections:

- 2.1 INTERROGATIONS
- 2.2 RECEIPTS AND RELEASES
- 2.3 ABORTS
- 2.4 ANSWER
- 2.5 SERVICE MESSAGES
- 2.6 QUEUES AND COMMUNICATION CONTROL DATA
- 2.7 SUMMARY

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(U) Table 2-1. COINS MESSAGE TYPES (U)

<u>Data Type</u>	<u>Message Type</u>		<u>Originator</u>	<u>Addressee</u>
1	INTG	Interrogation	System	System
1	ANSR	Answer to Interrogation	System	System
2	RCPT	Receipt	System or Switch	System or Switch
2	RLSE	Release	System	System
3	ABRT (ERROR)	Abort for Parity Errors	System or Switch	System or Switch
1	ABRT (CAUSE)	Abort for Hardware Errors	System	System
5	SRVC (READY)	{	System to Switch	
5	SRVC (BREAK)			
5	SRVC (PRINT)			
5	SRVC (BEGIN)			
6	SRVC (TRACE)		System	System
6	SRVC (TRACK)		System	System
4	SRVC (ALARM)		System or Switch	System or Switch
4	SRVC (CHECK)		System or Switch	System or Switch
4	SRVC (ALERT)		System	Switch
1	SRVC (LIMIT)		Switch	Network Controller and Originating System

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Each section discusses the informational requirements, the definition of the message-types, the related procedures (as stated in the COINS Principles of Operation), problems/inconsistencies encountered to date and where applicable, recommendations for changes.

2.1 INTERROGATIONS-INTG (U)

(U) An interrogation is one of the two basic messages that actually contains operational data that interacts with a human user. The INTG is used to ask a question of another system in the network. Its contents and syntax must conform to the requirements of the system being interrogated. Interrogations are checked for parity, proper format and proper procedure. If no problems are encountered, the standard sequence of message transmissions are made. Differences occur when error conditions are encountered. These differences are included in the discussion of ABRT messages.

(U) No changes to the INTG processing are being suggested or recommended.

2.2 RECEIPTS AND RELEASE-RCPT AND RLSE (U)

(U) Receipts and Releases are acknowledgements of the receipt of messages. In the case of receipts, it acknowledges the completion of transmission from one node to another for any type of message (except receipts). For all messages, the receipt also acknowledges that the message-type and the addressee fields contained recognizable values. In the case of INTG and ANSR, the receipt acknowledges that there was an acceptable level of parity errors.

(C) The RLSE message was originally intended to inform an interrogating system (the requesting user at his terminal) that the interrogated system has successfully received an interrogation and that

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the interrogating system may release its copy of the interrogation. The RLSE is only sent from one system to another. The switch does not generate RLSE messages. As was stated in our previous report, although RLSE is still used in the system, the RCPT has to a large extent preempted its function. Systems now release their copy of message when a RCPT is received instead of waiting for the RLSE. Notification of the user is based on receipts at NSA, but is based on releases at NPIC.

(C) The RCPT is used throughout the network as an indication of successful receipt of a message. If a RCPT is not received within a fixed time interval the message is retransmitted. This time interval and related procedures differ widely within the network. The switch now waits 120 seconds for RCPT of a message. DIA also expects a RCPT in 120 seconds. CIA will retransmit a message if no RCPT has been received in 50 seconds. If the second retransmission is not received in 50 seconds, the message is aborted. NPIC will wait up to 15 minutes for a RCPT. They will retransmit a message two times after original transmission.

(C) It is recommended that the RLSE message processing be standardized to include informing the user that the addressee system has received the interrogation. Further, it recommends that the Switch maintain a ledger file of interrogations for which it has not received a release message. When an appropriate time has elapsed (to be determined) for each system), the Switch would initiate a SRVC (TRACE). If the result of the trace operation indicates that the message has been lost, then the Switch should re-transmit the INTG from its ledger file.

(U) It should be noted that the revised use of the RLSE does not guarantee that the user will always receive a reply to the interrogation for the following reasons:

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- 1) The addressee system can fail and lose its queue including the INTG
- 2) The Switch can log out the ANSR because of a queue overflow
- 3) The Switch can log out the ANSR after a maximum number attempts to transmit it
- 4) The originating system fails and loses its queue and therefore cannot associate the ANSR with the user terminal.

2.3 ABORTS-ABRT (U)

(U) Abort messages are considered to be replies by the COINS Network because they are transmitted to the user. However, they are triggered in one case by transmission failures and by faults introduced in the INTG by the user.

(U) When transmitting information via communication lines, distortions frequently occur which require that error checking devices or procedures be provided. After the messages are received, integrity of the message, recovery of the message and other message protection facilities must be provided. There is frequently a misunderstanding between message and transaction validation. In transaction validation, checks are made to insure that the proper format, valid parameters, etc. are met. In message validation, which we have chosen to call message protection, provision is made to determine that the entire message has been received properly. Several techniques are available to insure message protection. They are:

- 1) Inclusion of and testing of parity bit for each character
- 2) Duplication of vital section of a message
- 3) Send every message two times
- 4) Compute, send and check horizontal parity "hash sum"

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The COINS Network only uses the first technique.

(U) There are three ABRT message subtypes:

ABRT (CAUSE)

ABRT (FAULT)

ABRT (ERROR)

(C) The ERROR subtype is used to indicate that parity errors were encountered in an interrogation or answer. This message is sent in lieu of a RCPT message. Transmission errors (detected as an unrecognizable message type) are handled by withholding both the RCPT and ABRT (ERROR) which should trigger a retransmission. When the Switch has received two consecutive ABRT (ERROR) messages for an INTG that it is forwarding to an addressee, it will stop transmitting the INTG and forward the ABRT (ERROR) message to the originating system. There is no limit to the number of ABRT (ERROR) messages that the switch will send. It does not count them. It is up to the sending system to count the retransmissions and inform the user of the ABRT (ERROR) situation. DIA will attempt to retransmit a message only two times. CIA uses the FAULT message to indicate parity errors.

(U) The ABRT (FAULT) message is used to indicate an error in the format of an interrogation. It is generated by the addressee system. A FAULT message, if required, would normally follow a RCPT and RLSE message.

(C) The ABRT (CAUSE) message is usually an indication of hardware problems. It counts as a reply to an interrogation. If a CAUSE message is generated by a destination system it will have been preceded by a RCPT and RLSE. CIA uses the ABRT (CAUSE) if interrogation queues are filled. It would seem that the SRVC (ALARM) was intended for this purpose.

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(C) It is recommended that the abort-type messages should be expanded to include other types of malfunctions such as lost messages such as ANSR's that cannot be matched to an INTG.

2.4 ANSWER - ANSR (U)

(U) The answer, as the name implies, should be the successful product of an interrogation. It is forwarded through the Switch back to the system originating the interrogation.

(U) No changes to the ANSR processing are being suggested or recommended.

2.5 SERVICE MESSAGES-SRVC (U)

(U) Service-type messages are used to check and exchange information about the status of the Switch, the component systems and the communication lines that connect them. There are nine SRVC message subtypes:

- 1) SRVC (READY)
- 2) SRVC (BREAK)
- 3) SRVC (PRINT)
- 4) SRVC (TRACE)
- 5) SRVC (TRACK)
- 6) SRVC (ALARM)
- 7) SRVC (BEGIN)
- 8) SRVC (CHECK)
- 9) SRVC (LIMIT)

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2.5.1 SRVC (READY)/(BREAK) (U)

(U) The READY and BREAK messages are used for starting and stopping operations. These messages are not sent from one participating system to another. They are always sent between one participant and the Switch. The Switch then forwards the status (READY/BREAK) to all other Systems. Once a system is in BREAK status, it must transmit a READY to the Switch to re-join the network. The Switch may put a system in BREAK status if communications problems are indicated due to failure to receive receipts for the CHECK messages it sent to the system.

2.5.2 SRVC (PRINT) (U)

(U) The PRINT message is used to send messages to the console operators at the Switch and the systems in the network. The switch uses the PRINT message to communicate ALARM conditions to participating systems.

2.5.3 SRVC (TRACE)/(TRACK) (U)

(U) The TRACE and TRACK messages are used for message tracing. If an INTG has been outstanding for an excessively long period of time, the user at the originating system may send a TRACE message to the addressee system. The system's response will be a TRACK message indicating whether the message is active or there is no record of the INTG

2.5.4 SRVC (ALARM)/(BEGIN) (U)

(U) The ALARM and BEGIN messages are used for network overflow prevention. An ALARM is sent when there is a danger of running out of buffers. The recipients are expected to refrain from

sending any non-receipt-type messages. When a systems in the network send a ALARM to the Switch, the Switch then suspends transmission to that system and forwards the ALARM to the other systems. The participating systems will suspend transmission of all but RCPTs to the system in ALARM. status. The ALARM status is lifted when a BEGIN transmitted from the system in ALARM status.

2.5.5 SRVC (CHECK) (U)

(U) The SRVC (CHECK) message is used to test the status of the COINS network lines. It is sent by the Switch to each participating system in READY status every 120 seconds. If a system does not send a RCPT for the SRVC (CHECK) to the Switch in a timely manner, it is put in BREAK status by the Switch and a SRVC (BREAK) informing the other systems is sent out. Failure to send a RCPT for a CHECK may be due to failure of the system or to failure of one or both of the communications lines. If a system or its receive line is out, it obviously will not receive the CHECK message. If its outgoing line is down, it may, indeed receive the CHECK message and generate a RCPT for it. The RCPT, however, cannot reach the Switch. The CHECK message is intended to detect just such problems. It should be noted that the COINS Principles of Operation states that the SRVC (CHECK) message is also available to the systems in the network for a similar purpose.

2.5.5.1 Problems. (U) Problems have arisen because systems have failed to send a RCPT for other reasons such as when processing requirements of previous messages have prevented a system to send a RCPT to the Switch in a timely manner. As a result, the system was put in BREAK status needlessly.

(U) The solution to this problem as well as the accompanying problem of determining which line is down when communications problems do exist involves:

- 1) Modification of procedures used at Switch for generation of SRVC (CHECK) message.
- 2) Timely transmission of RCPT of CHECK messages by participating systems.
- 3) Implementation of procedures at the Switch and at participating systems to insure rapid and accurate diagnosis of communications problems when they do occur.

Considerable discussion of this problem has taken place during and outside of CCIP meetings and some accord has been reached. The panel members, therefore should be given credit for recognition of the problem and their efforts toward its solution. What remains to be done is to make a definitive statement of the solution with some alternative enhancements to expedite diagnosis of problems detected by the use of the SRVC (CHECK).

2.5.5.2 Modification of Procedures Used at Switch for Generation of Check Messages. (U) The Switch currently sends a SRVC (CHECK) message every 120 seconds to all active systems. The Switch should send a CHECK message to a system only if there has been no incoming traffic from that system for 120 seconds. (whether active or in the BREAK status). If the Switch does not receive a RCPT for the CHECK message within 240 seconds, a SRVC (PRINT) message should be sent to the Network Controller and the system operator informing them of the condition. After two more times, the system should then be put in BREAK status and the resulting SRVC (BREAK) message sent to the other systems. It would be the responsibility of the switch operator to get in touch with the operator of the system put in BREAK status to determine if he received the SRVC (PRINT) sent prior to going into BREAK status. If the PRINT was not received,

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there is definitely a problem with the line coming into the system and possibly a problem with the line going out. If the PRINT was received, the problem is probably in the line going from the system to the Switch and the incoming line may be all right. In either case, the communications people at the Switch and at the system should be notified. When the system recovers, it can RCPT for a CHECK message which will cause the Switch to put it in READY status and broadcast it to the other systems.

(U) The possibility of using an ALARM instead of a BREAK should be considered. If ALARM were used, other systems in the network would know that the Switch is holding up all traffic for the system in ALARM status except for RCPT's. Procedures would still have to exist, however, to put the system in BREAK status if the time required to correct the problem were of considerable duration. Once the system is in BREAK status in this case, it must send a SRVC (READY) to the Switch in order to rejoin the network.

2.5.5.3 Timely RCPT of CHECK Messages. (C) The suggested modifications to procedures for generation of SRVC (CHECK) message by the Switch should reduce the probability of a system being unnecessarily put in BREAK status. It is still incumbent upon the participating systems to send a RCPT for a CHECK message in a timely manner. Processing of incoming CHECK messages should be given priority over normal traffic if the four minute interval allowed by the Switch for RCPT of a CHECK message cannot otherwise be met. CIA currently processes incoming messages on a first-in, first-out basis. CIA also responds to a BREAK message by sending a READY message to the Switch. This should prove unnecessary if a BREAK is only issued in the case of detection of communications problems.

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2.5.6 SRVC (ALERT) (C)

(C) The ALERT message is used to indicate non-receipt of messages and a possible communications failure. The Switch currently uses a SRVC (PRINT) in place of the ALERT to indicate such problems to operators at other systems. The Switch considers ALERT conditions to exist when:

- 1) A message is unrecognizable after three times at transmission.
- 2) An incoming non-INTG message has an average of more than 35 parity errors in a segment.
- 3) A message is not received within 120 seconds of line availability time.

The SRVC (ALERT) is not issued by DIA. NPIC will issue an ALERT if a parity error is detected in the Addressee field of a message or if more than 4 parity errors are detected in any segment of a message.

2.5.7 SRVC (LIMIT) (U)

(U) The LIMIT is used to report error conditions due to oversize messages. (greater than 100 segments). The message is sent to the system that sent the overlength message.

2.6 QUEUES AND COMMUNICATIONS CONTROL DATA (U)

(U) At times messages will be received so rapidly from the input devices that the network cannot keep pace with the processing of all of the messages. When this condition occurs, the switch and systems must store the input messages either in core memory or on mass storage devices and generate a list of messages to be processed and where they are stored. This list is called a queue. If input messages continue to be received in such profusion that the system

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falls further and further behind, some sort of action must be taken or a system overload will develop. The same condition can also occur on output.

(U) Message accountability requires that both hardware and software facilities be used. Some examples of the software techniques for message accountability follow but this should not be considered a complete list.

- 1) Acknowledgement that the message has been received - After correct receipt of message, system accountable for message.
- 2) Message sequence number - by system and terminal
 - A) Continual check to insure each number is consecutive
 - B) Out-of-sequence or missing numbers indicate error.
- 3) Ledger balancing - Maintain a ledger of input and corresponding output messages for each transaction.
- 4) Message release - Reverse of 1. Responsibility for message not released until the receiving unit acknowledges proper receipt.
- 5) Previous reply - Another technique is used to account for messages in the conversational mode. No message count is used in this system but rather the reply to the previous response is used as the accountable technique. If the response is not that which is desired, the operator may request a restart and the computer system must be designed to go back to a certain point and start again from that particular point.

(U) In COINS, a priority is assigned to messages. This in effect means that lower priority processing will be delayed to process the higher level priority messages. A priority queue list must be determined for each priority level. Without priority assignments, the first message in is the first message to be processed. This is also true in a priority system but only within the individual priority

level. The first message of priority 1 would be processed before the second message with the same priority. However, priority 2 messages would take precedence over priority 1 messages even though they might have been received at a later time. Since high priority messages could in effect block processing of all messages of a lower priority if they were to occur in abundance, another control is sometimes exercised in other systems. After a certain period of time, the priority of a message will be increased if it has not been processed. This is done to insure that low priority messages are given consideration. The changing of priorities does increase the programming complexities and core storage requirements. Priorities may have little effect on communications especially if the message is processed at a later time.

(U) In COINS, the message length is fixed. In other systems, messages may be of different lengths. The objective of the system analyst is to determine the length of the majority of the messages to properly allocate core buffer sizes for each of the lines. If the buffer, which is a series of core positions which have been set aside to receive or transmit messages, is too long, core memory is wasted. If the buffer size is too short, the message must be segmented, stored either in core or on mass random storage or both and linked to the previous segment. This requires additional computer processing. Therefore, the goal is to derive the optimum size buffers to handle the greatest majority of the input and output messages.

(U) No suggestions or recommendations are being made in this area because the queueing in the Switch is undergoing a major revision.

2.7

SUMMARY (U)

(U) The estimated cost for the recommended changes are summarized below. The first column identifies the section which contains the improvement.

(U) In general the participants should examine and define their individual procedures for handling the various message types. The definitions should be combined with those of other participants and inconsistencies noted. This information should prove useful in future discussions of problems and improvements to the network. As individual systems are modified or upgraded, they should attempt to more closely conform to an agreed-upon standard.

<u>Section</u>	<u>Recommendation</u>	<u>Cost</u>
2.2	Inform Users that RLSE message for interrogation has been received	4 man-months each system
2.2	Create Switch Ledger File for interrogations waiting for RLSE messages	5 man-months
2.2	Enable Switch to initiate TRACE when RLSE is not received in timely time	4 man-months
2.3	Enlarge ABRT-type categories	3 man-months for switch and each system
2.5	Modify SRVC (CHECK) procedures in Switch	1 man-month
2.5	Modify RCPT of CHECK messages at the Systems	2 man-months for each system

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SECTION 3

COINS DATA COLLECTION AND ANALYSIS (U)

(U) The Study Team has reviewed the data collection and analysis activities associated with the COINS activity. The initial investigation was accomplished during the system programming conference at each of participating members. Subsequently, a member of the team participated in the meetings of the COINS Test and Analysis Panel. Finally, exploratory queries were prepared and processed against the LOGGA file which contains a history of the message traffic for on-line analysis.

3.1 EXISTING PROCEDURES (U)

(U) Data collection for COINS occurs in each of the systems and in the COINS switch. There are four types of records:

- 1) Network Activity Log and LOGGA File
- 2) COINS Users Log Sheets and MTARA File
- 3) System Operating Logs
- 4) System Operator Logs

3.1.1 Network Activity Log and LOGGA File (U)

(U) The LOGGA file is the primary source for operational statistics for the COINS Experiment. It is created from the raw data collected in the Network Activity Log. The Network Activity Log contains a record for each message processed by the network switch. It records the time for five basic events within the switch's processing cycle. The contents of both of these files are listed in the COINS Principles of Operation Handbook dated 31 July 1969. Therefore it is not necessary to repeat that data in this study.

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(U) The Network Activity Log is updated with a record for each message that it forwards from one system to another. At this point, no attempt is made to match or correlate the various messages related to an interrogation.

(U) At the end of each working day, the Network Activity Log is used to update the LOGGA File. Not only are the day's data added to the file, but they are processed prior to being added. Three types of records that are used only for DIA processing are deleted; HOST, LIST and CANCE. In addition, the records are sorted by Reference ID number so that the ABORT, ANSR and INTG can be related and the INTG record can be augmented with the times associated with ABRT or ANSR. This process is illustrated in Figure 3-1. The INTG record in the LOGGA file is significantly longer than its counterpart in the Network Activity Log. The processing into an integrated INTG record is very useful because it permits an analysis of the utility of system in terms of responding to requests for data.

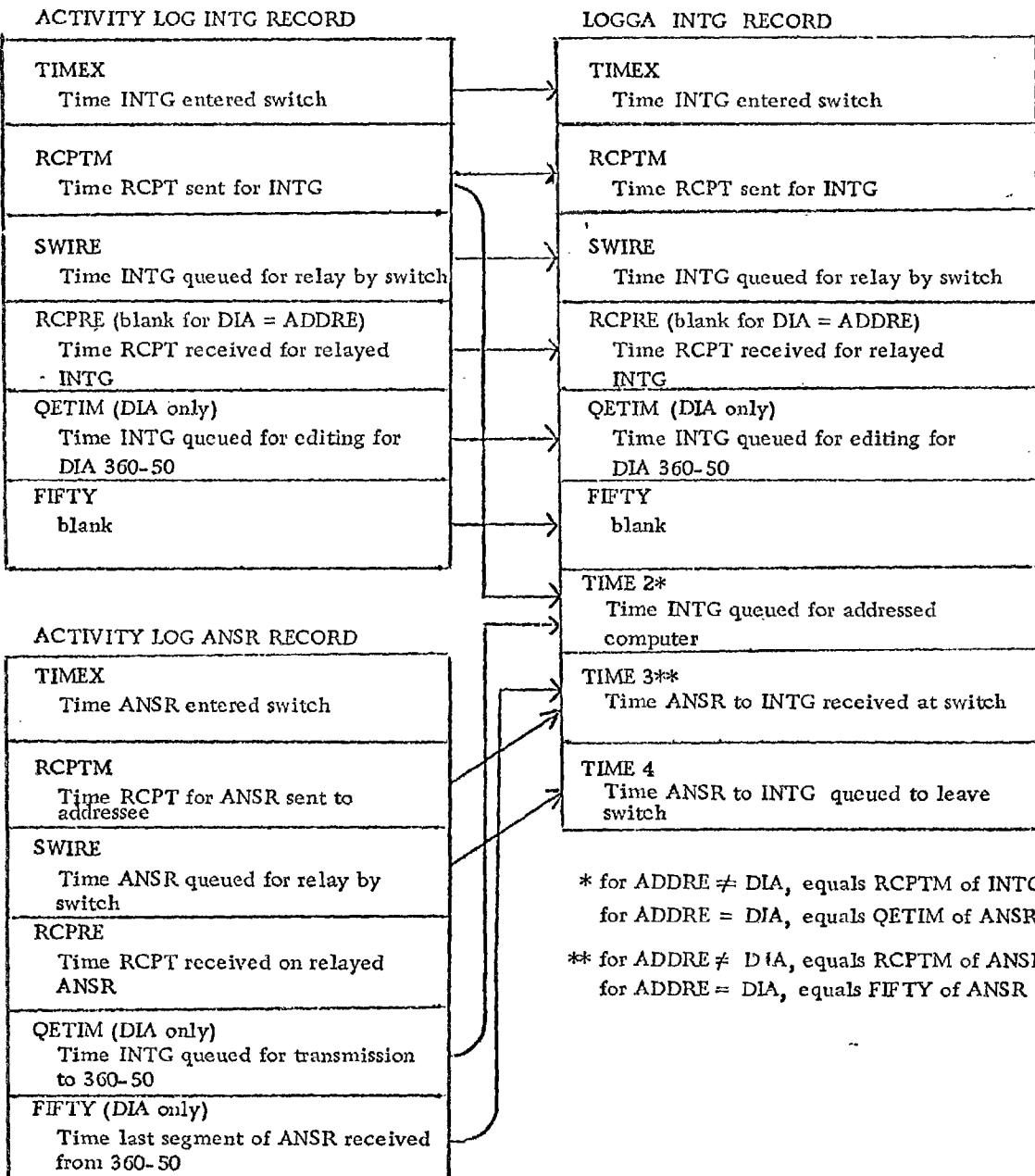
(U) Figure 3-2 illustrates the processing required for an ANSR record in the LOGGA file. Processing similar to that for the ANSR is accomplished for ABRT, RLSE, RCPT and SRVC messages.

(U) The recording of message lengths (measured in terms of number of segments) requires some explanation. Each LOGGA record has two length fields: one for the message (LNGHI) and one for the associated reply (LNGHA). The following tabulation defines the fields for the various message types in the LOGGA File:

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Figure 3-1. Definition of INTG Record in LOGGA File



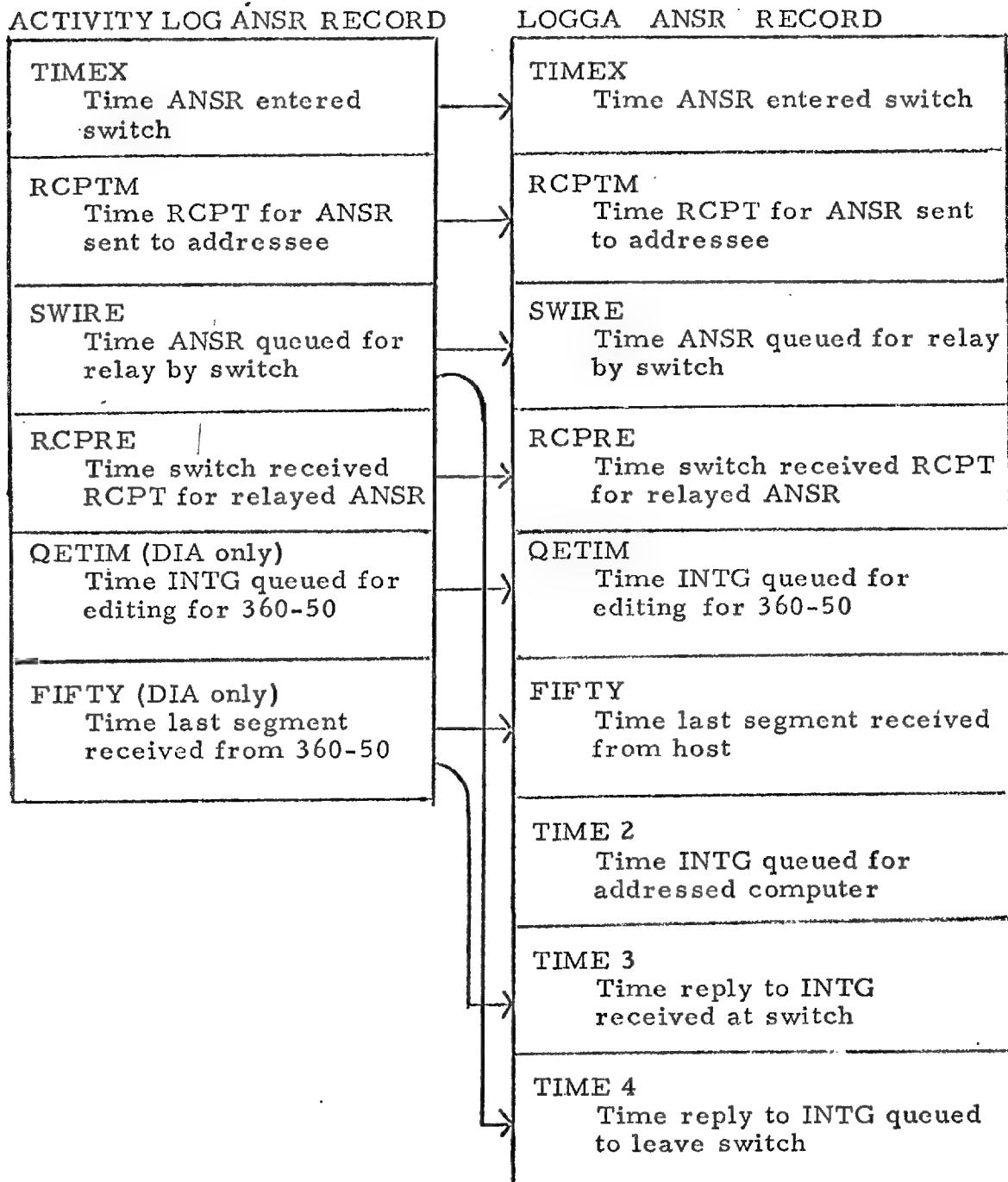


Figure 3-2. Definition of ANSR Record
in LOGGA File

<u>Message Type</u>	<u>LNGHI</u>	<u>LNGHA</u>
INTG	Length of INTG	Length of associated ANSR or ABRT
ANSR ABRT RLSE SRVC	Length of message non-DIA	N. A.
ANSR ABRT RLSE SRVC	Length of message if >1 Blank if =1 DIA	N. A.

(U) LOGGA provides:

- 1) A record of INTGs received by the switch.
- 2) A basis for determining system response; i.e., answered, aborted for fault or error, or never answered.
- 3) A basis for measuring elapsed time for various switch-type operations, such as preparing receipts.
- 4) A basis for counting housekeeping-type messages such as Release and Service messages.
- 5) A basis for estimating total traffic handled by the switch measured in terms of segments and messages.
- 6) A basis for tabulating detected transmission and parity errors.

(U) However, the LOGGA file does not contain any data concerning the processing performed by the Host and Addressee computers. There are several reasons why this data is not available:

- 1) Clocks at the various systems cannot easily synchronized. Therefore elapsed time for non-switch computer processing cannot be reliably determined.
- 2) Any INTG or ANSR that fails to be received by the switch is omitted from the LOGGA file since LOGGA only reflects switch activity.
- 3) Time is recorded in rather large intervals such as half-seconds and thousandths of an hour. These are too gross to use for many of the measurements that an analyst would like to have.

(U) The COINS switch has different processing paths for its traffic as a function of the host and addressee systems. Figure 3-3 illustrates the various steps involved when a user at one non-DIA agency queries a file at another non-DIA agency. The labels of the time fields recorded in the LOGGA file are shown in the figure. Figure 3-4 illustrates the processing performed when a DIA user queries a file at a non-DIA agency. It should be noted that the DIA computer is not involved because the COINS switch services the DIA terminals.

(U) Figure 3-5 illustrates the processing performed when a user at a non-DIA agency queries a DIA file. It is important to note that no receipts are exchanged between the DIA computer and the switch. The reason is that the transfer of messages occurs over a high-speed adaptor line rather than over communication lines and that it has proved to be very reliable. The system designers have done an excellent job of defining equivalent points in the switch's processing for the three processing paths shown in the three figures. (It should be noted that when ANSRS becomes the DIA system, all processing will follow the flow shown in Figure 3-3.)

(U) The DIA system programmers have prepared quite a few RIT's for querying the LOGGA File. An RIT permits an analyst to specify an RIT identification and the values for the selection parameters, rather than a complete complex query. He then receives the results of the retrieval presented in a pre-defined format.

(U) One of the most frequently used RIT's is the one identified as LOGAR. In most cases, the analyst specifies the dates to be encompassed by the report. The resulting report has four parts:

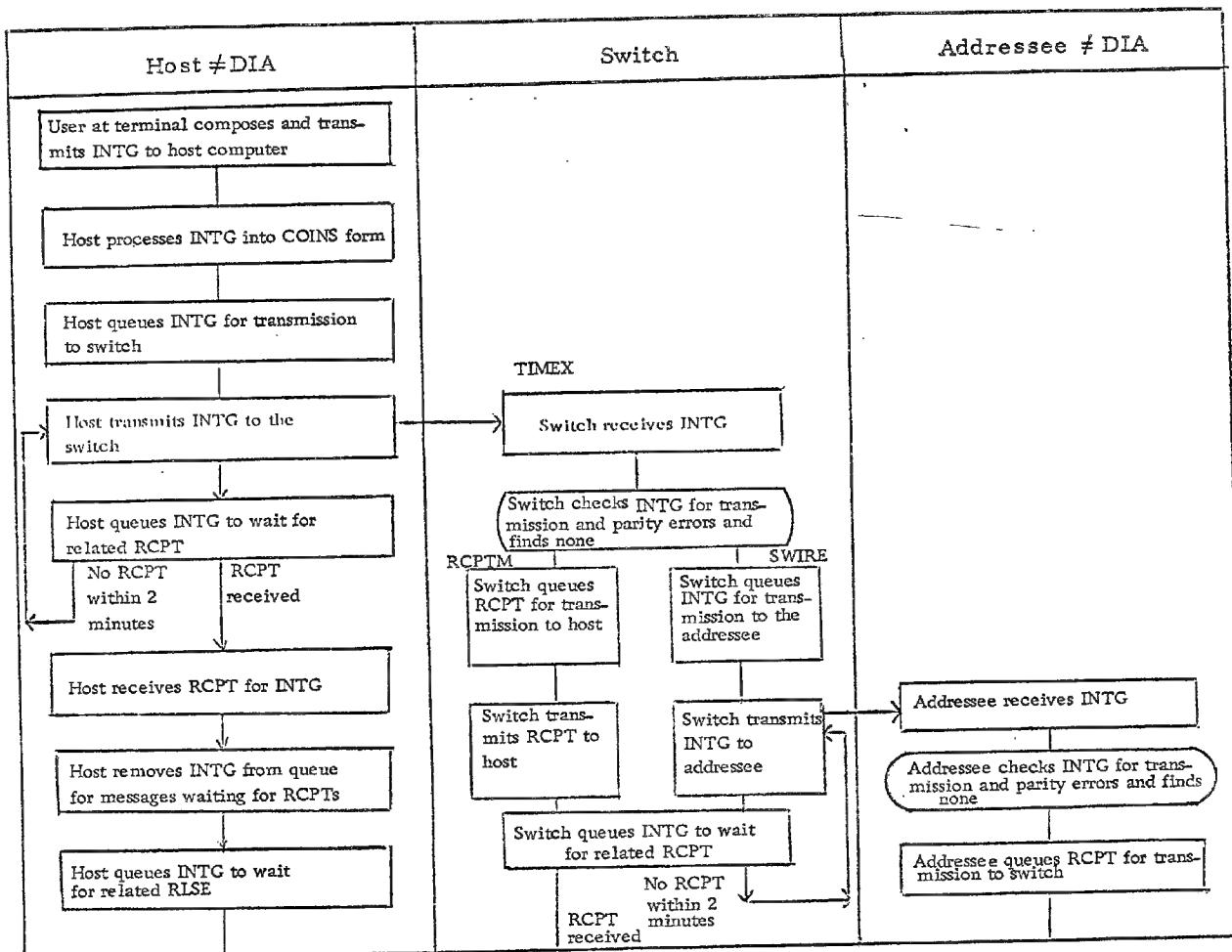


Figure 3-3. COINS Processing with Host and Addressee ≠ DIA (Page 1 of 3) (U)

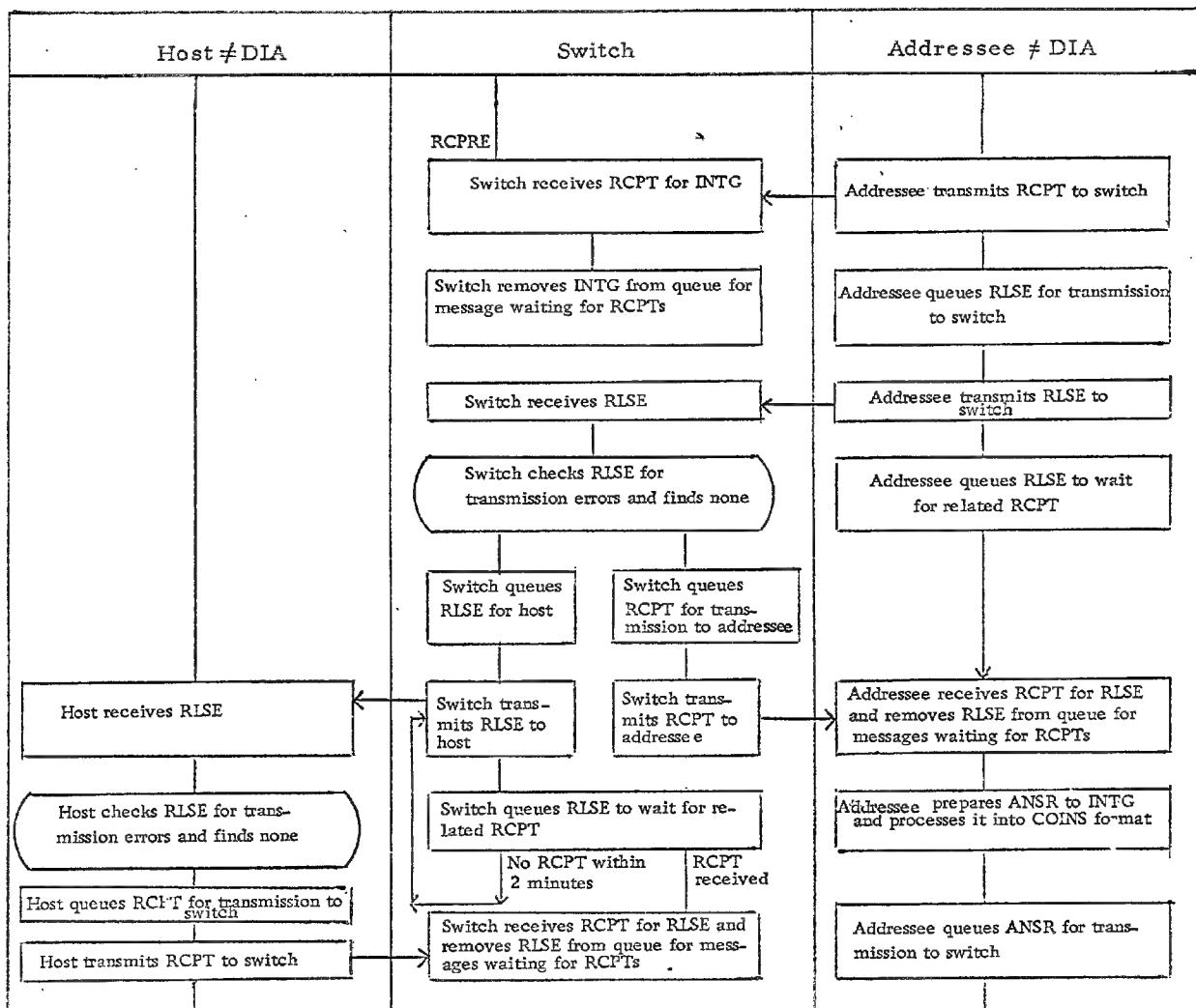


Figure 3-3. COINS Processing with Host and Addressee ≠ DIA (Page 2 of 3) (U)

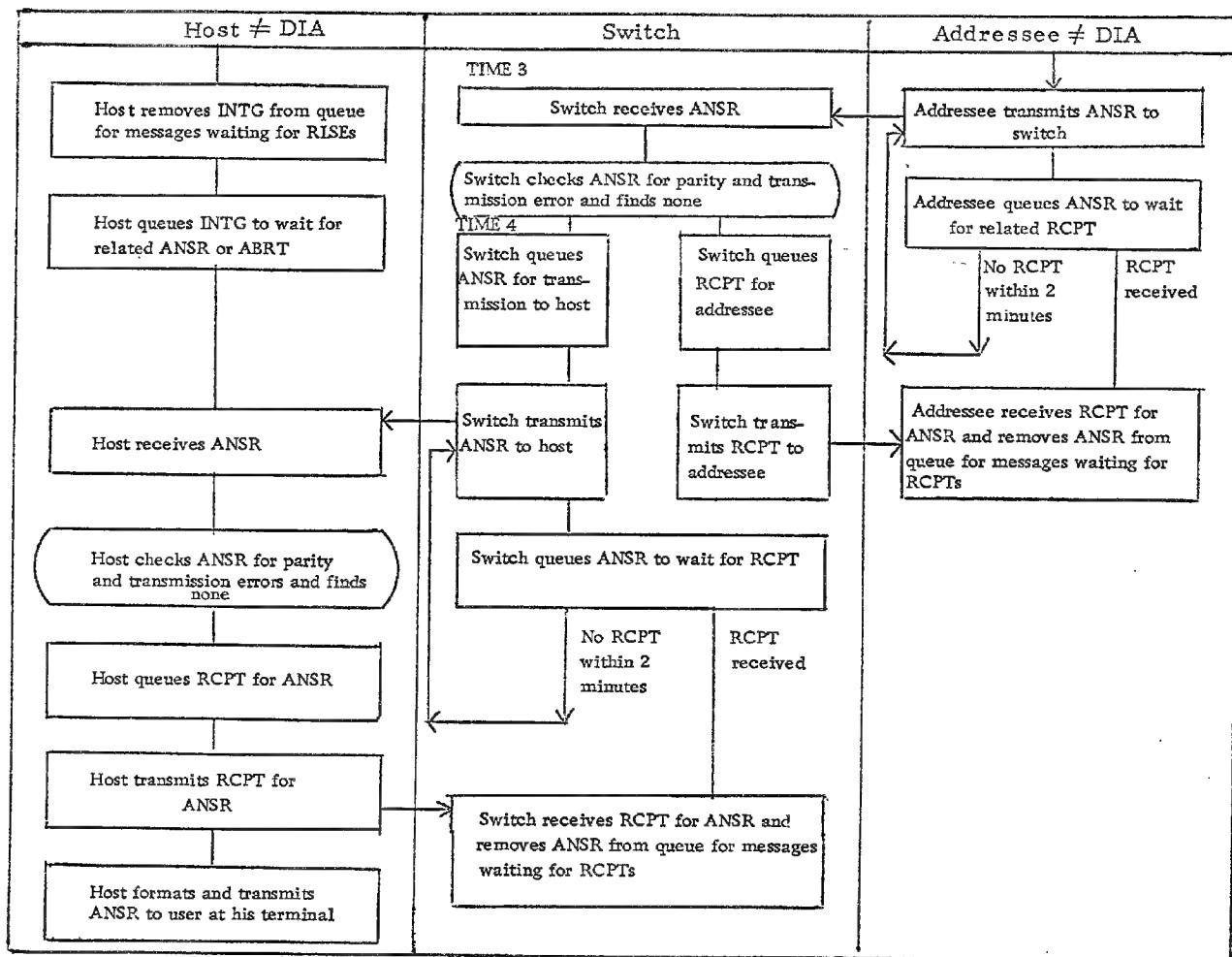


Figure 3-3. COINS Processing with Host and Addressee ≠ DIA (Page 3 of 3) (U)

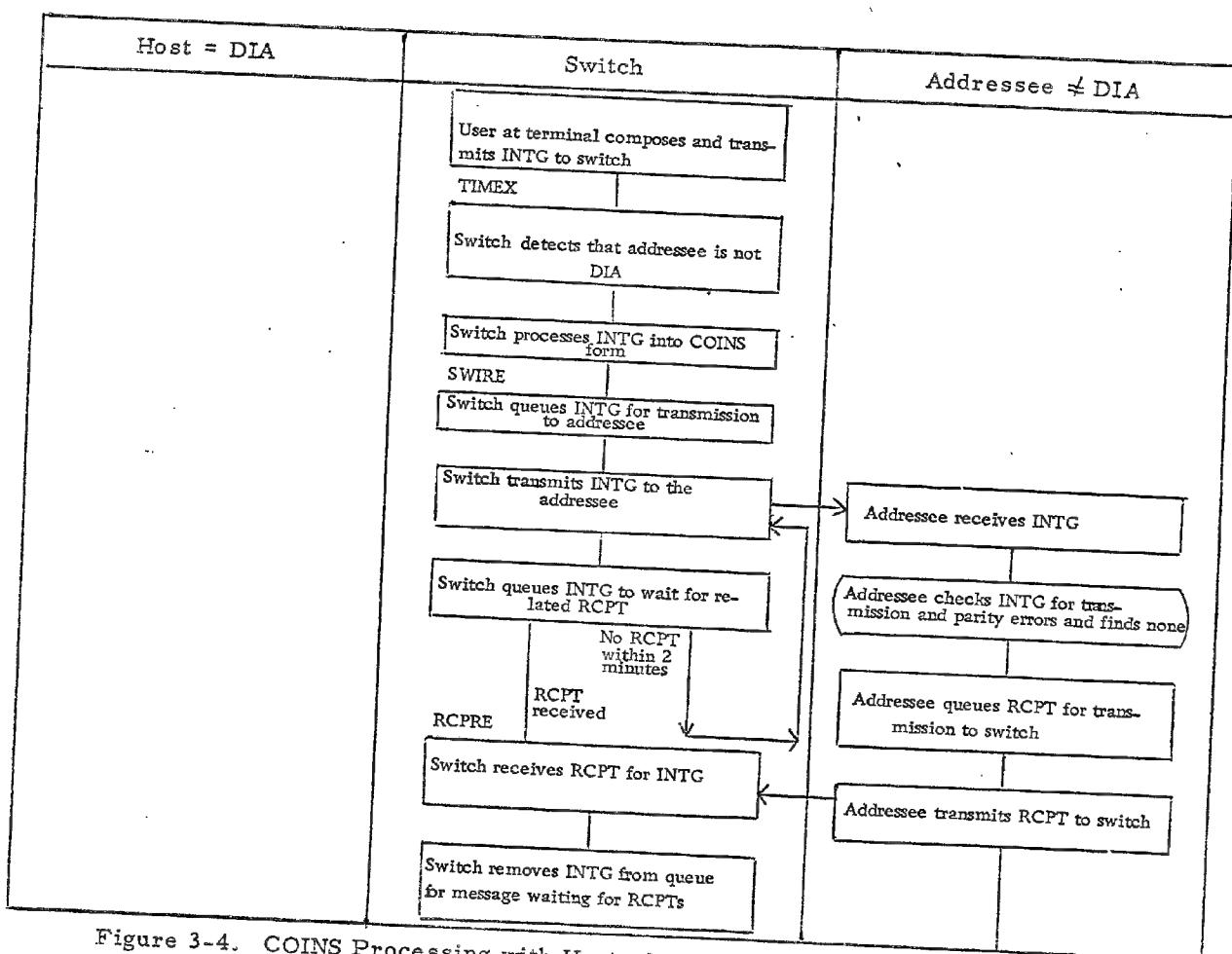


Figure 3-4. COINS Processing with Host = DIA and Addressee ≠ DIA (Page 1 of 3) (U)

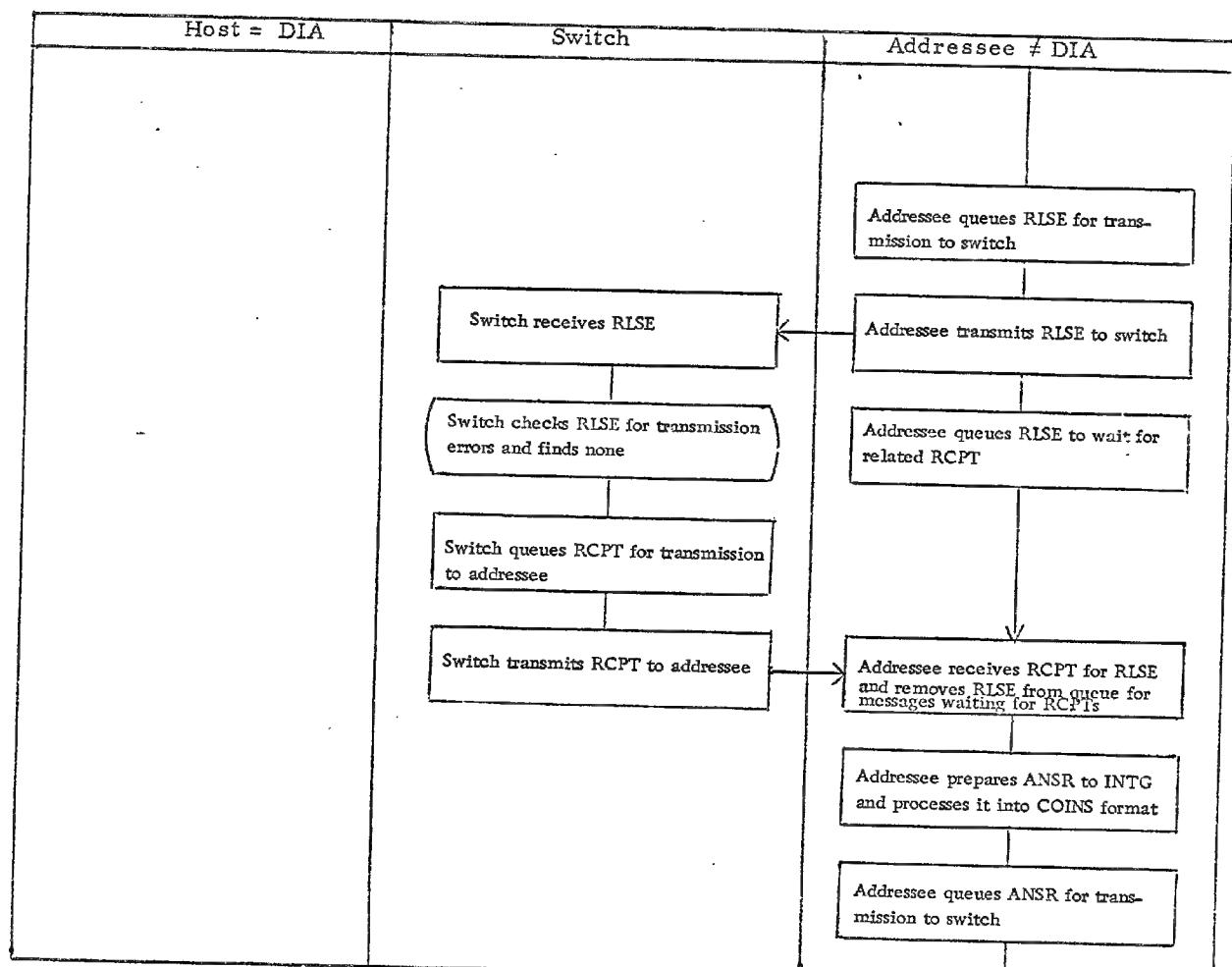


Figure 3-4. COINS Processing with Host = DIA and Addressee ≠ DIA (Page 2 of 3)(U)

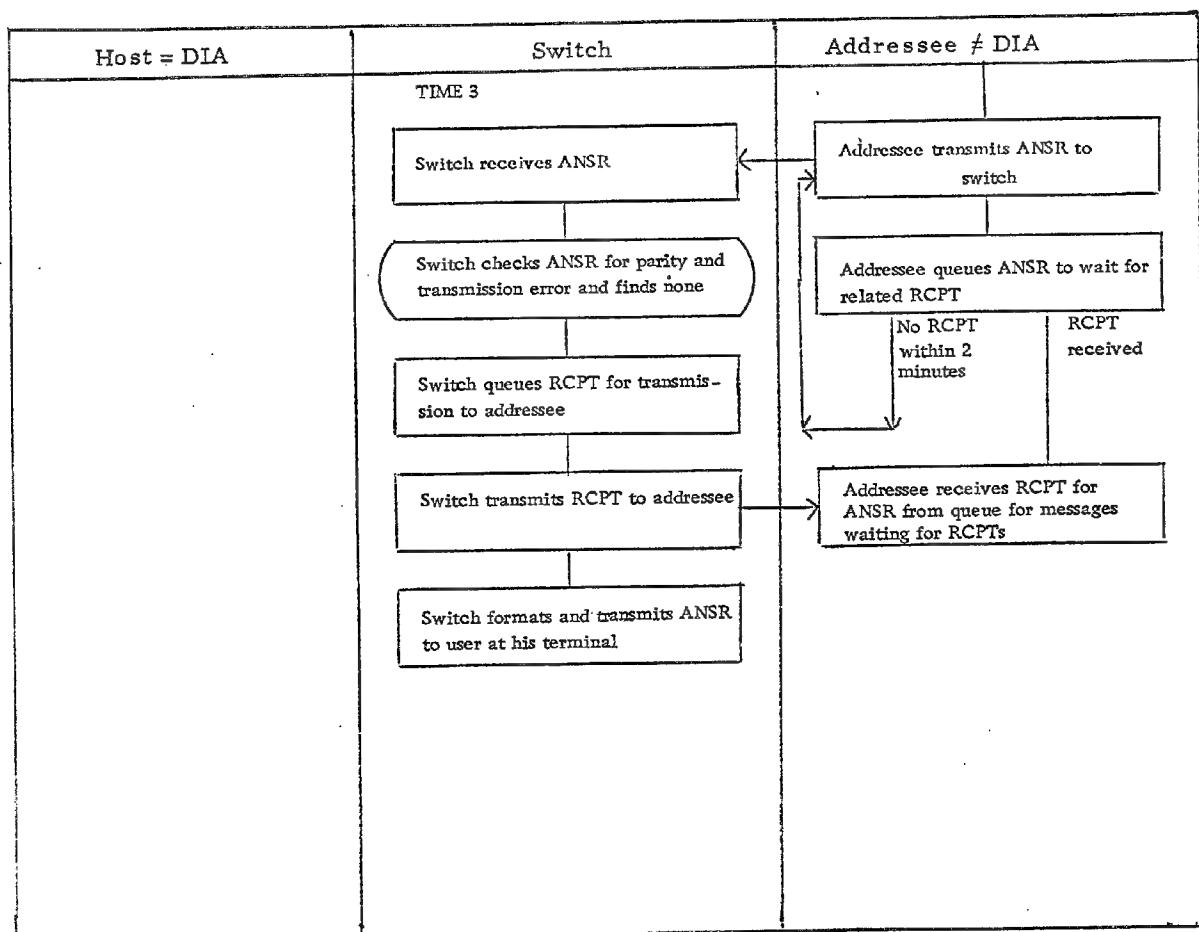


Figure 3-4. COINS Processing with Host = DIA and Addressee ≠ DIA (Page 3 of 3)(U)

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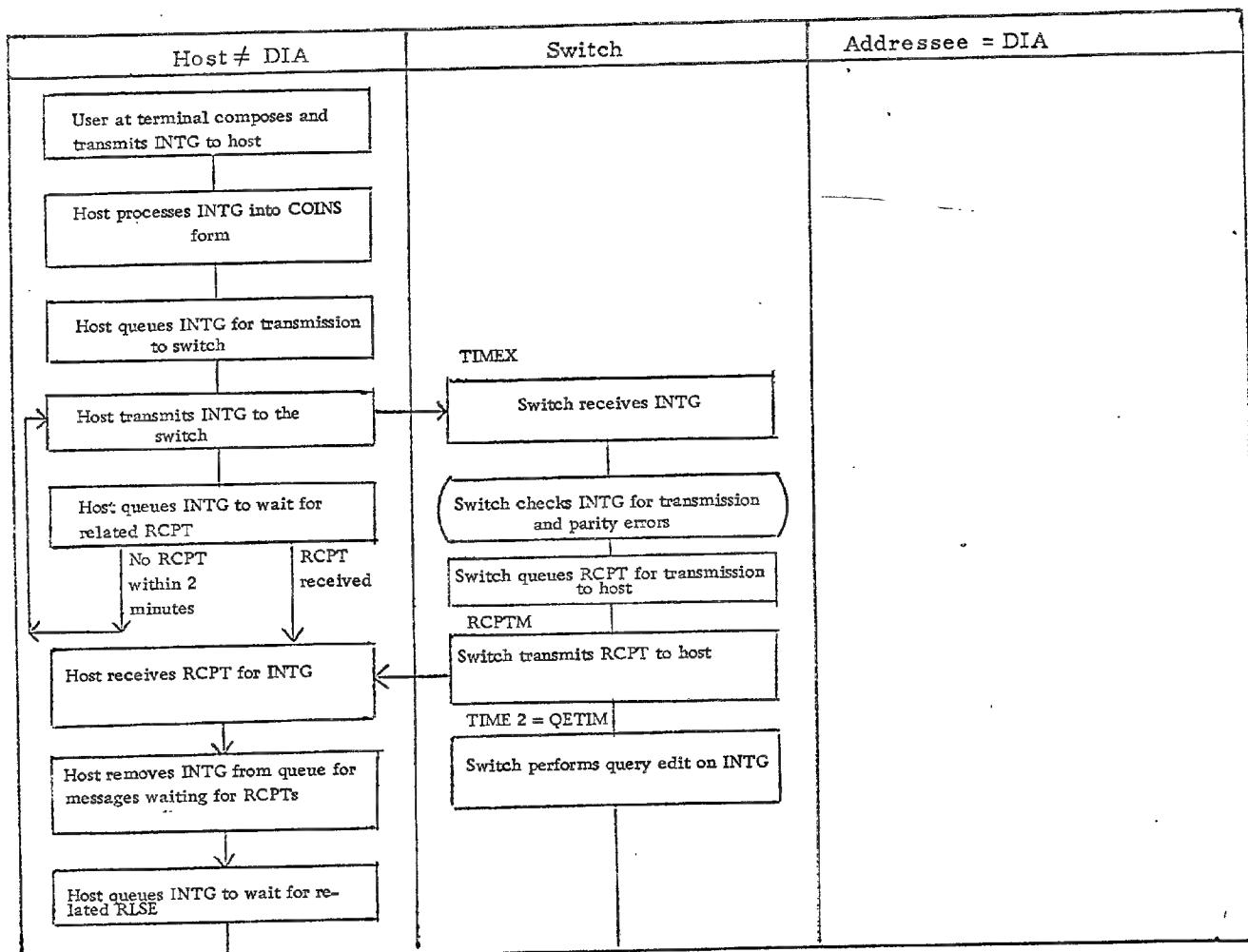


Figure 3-5. COINS Processing with Host ≠ DIA and Addressee = DIA (Page 1 of 3) (U)

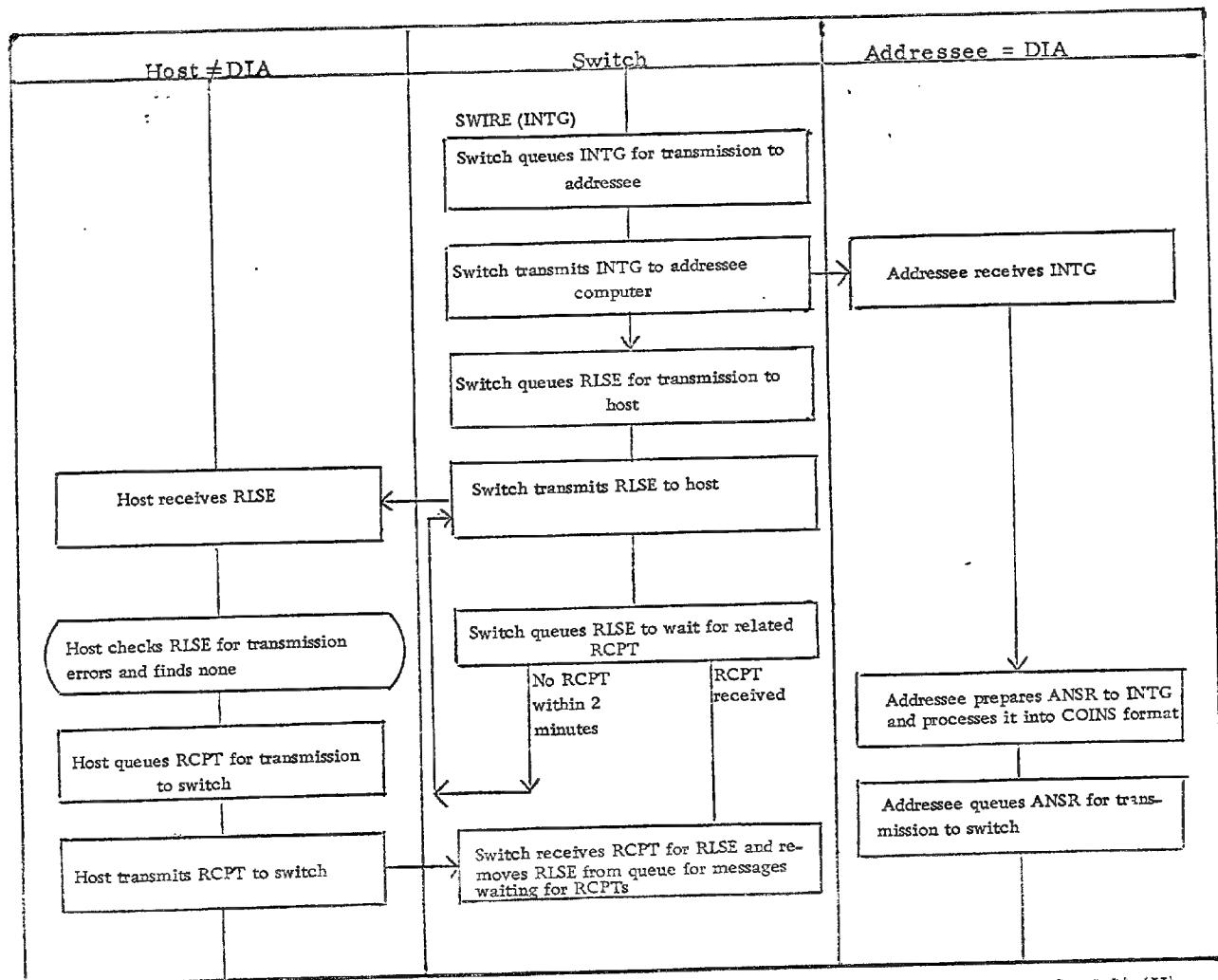


Figure 3-5. CCINS Processing with Host ≠ DIA and Addressee = DIA (Page 2 of 3) (U)

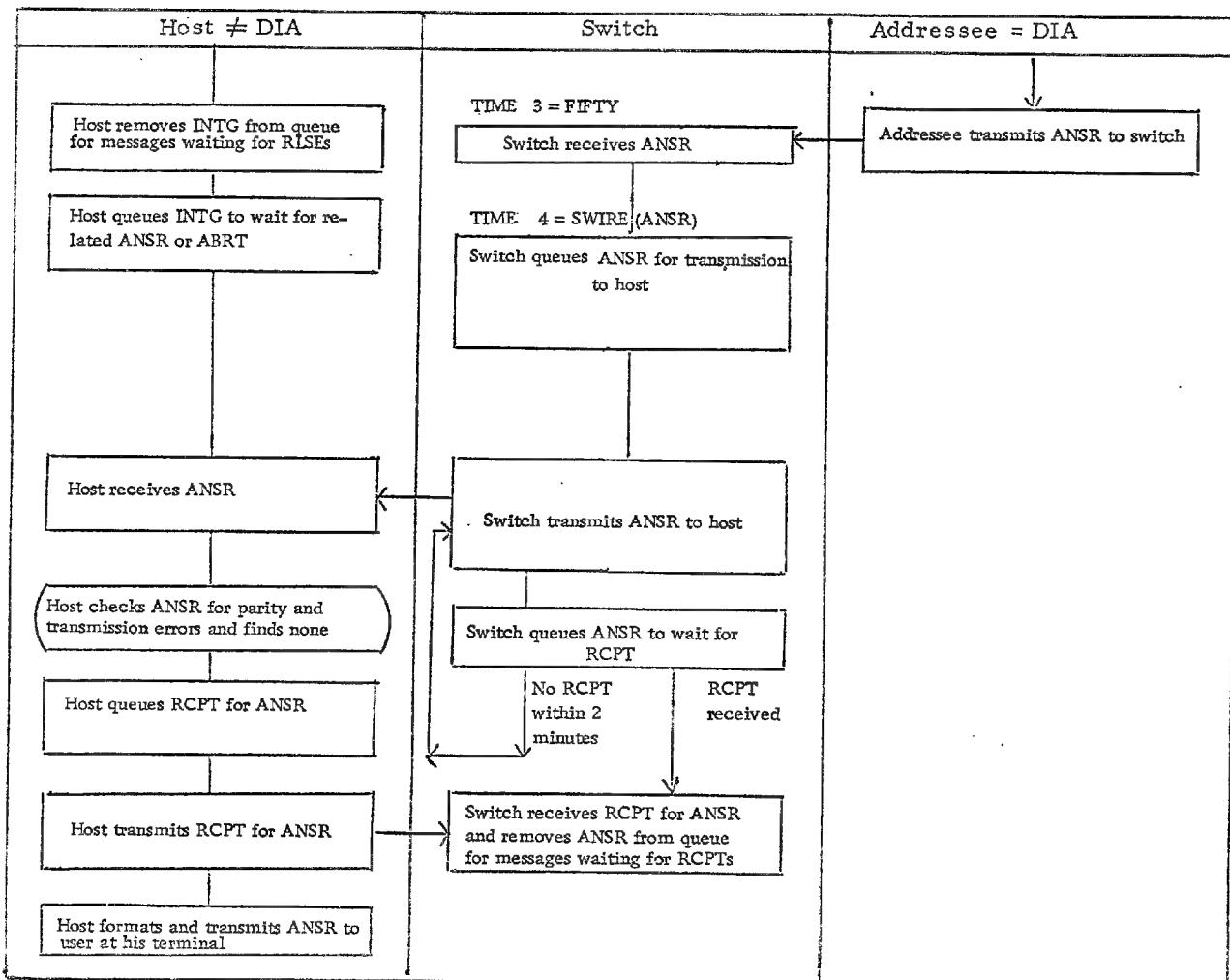


Figure 3-5. COINS Processing with Host ≠ DIA and Addressee = DIA (Page 3 of 3) (U)

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- 1) Counts of messages by message type and a total of all segments in the system
- 2) Average query response time for each agency
- 3) Counts of interrogations by host and addressee systems
- 4) Counts by host and addressee systems of interrogations for which replies (ANSR or ABRT) were received

The LOGAR processing recognizes the characteristics of the integrated INTG-type records in the LOGGA file and its message and segments counts are appropriately adjusted. For this reason, the LOGAR RIT cannot be used to derive counts of messages by message length. Similarly the response time cannot be used as a selection parameter.

(U) There has been some criticism of the COINS statistics because all DIA-to-DIA and some CIA-to-CIA traffic is included in LOGGA file. This occurs because the COINS switch services all DIA terminals regardless of whether they are requesting DIAOLS or COINS service. There is some feeling that a request from a DIA user for data from a DIA COINS File should be omitted from the statistics, since similar traffic at the other agencies does not use the switch and therefore is omitted from the statistics. This criticism will disappear when ANSRS replaces DIAOLS because DIA-to-DIA traffic will then by-pass the switch. In this case, the DATANET-30 will service the DIA terminals and will screen the traffic and only forward non-DIA traffic to the switch. DIA traffic will be sent directly to the ANSRS computer.

3.1.2 COINS User Log Sheets and MTARA File (U)

(U) In order to provide missing time data, the Test and Analysis Panel created a COINS User Log sheet. Its purpose was two-fold: one, to collect the elapsed time data as experienced by the

user and; two, to acquire users reactions to COINS. Sampling procedures were created and the MTARA File was defined. The MTARA File combines the data from the LOGGA file with the user's input from the COINS User Log sheets. The message ID number was used to match the two types of data. In this way, the MTARA File could be used to compare the system performance with user's evaluation of his results. Experience to date indicates that the users are not sufficiently motivated to fill out the sheets. In addition, it was found that the sheets that were filled out were inaccurate and frequently incomplete.

(U) The MTARA File, however, continues to be useful. After several months of test, the LOGGA has been purged of earlier data. So now the MTARA File is the COINS history file. Queries against it are generally processed in the batch mode. However, DIA currently is preparing some RITs for on-line use of the file.

3.1.3 System Operating Logs (U)

(U) Each of the Coins systems maintain logs of its COINS traffic. These are normally printed at the end of the day in the batch mode. The listings are usually reviewed by a systems programmer for abnormalities in the data or for answering questions from a user. These listings are usually retained for a few days and then destroyed. However, the switch log listings have not been destroyed. DIA has a safe filled with them.

(U) These logs serve several purposes. First, they provide the basic data for tracing an interrogation through the system and noting the processing it encountered in the host computer. Second, it serves as a record of the SRVC (READY) and SRVC (BREAK) messages sent and received by the system. This assists in the tracing of the traffic and determining causes for lost messages.

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(U) These logs will be useful in determining causes for some of the lost messages and for determining elapsed time for processing. However, at least one system log only records the first segment of each message. This means that analysis of message lengths and contents cannot be done.

3.1.4 System Operator Logs (U)

(U) Each of the systems maintain a COINS Operator Log which chronicles the status of the COINS system during the day. It indicates whether the system is up or down and the cause for being down (using such categories as computer, communications lines or software). It contains a record of the times when the system was re-initialized (and thereby losing its queue).

(U) These logs have the same problem as other operator logs in terms of completeness and reliability. This is because the system is depending upon a person to remember to record the event at the same time as it is pressuring the same person to diagnose a fault and take corrective action. In spite of these difficulties, operator logs are useful for gross measures of system reliability.

3.2 RECOMMENDATIONS (U)

(U) The recommendations are devided into three parts:

- 1) Changes to the message formats
- 2) Changes to the LOGGA File
- 3) Additional analyses to be made

3.2.1 Changes to the Message Formats (U)

(U) Several changes to the message formats are suggested to provide a more complete record of the processing of a message. The first suggestion is that a user-time be added to the header of every message. For INTG and SRVC (TRACE) messages, this time would be defined as the time the last character of the message was received by the computer. For other messages, it would be defined as the time the related triggering action occurred (such as successful check for transmission errors before RCPT is queued). The Study Team recognizes that the clocks at the various systems are not synchronized at present and therefore no meaningful data can be derived from this one change. However, this problem is being discussed by the Subsystem Managers and a solution may be available in the next few months.

(U) The second change to the message formats is the creation of new message type - SENT. This message would be created by the host systems upon the completion of the transmission of a reply to the user. Reply would be defined as an ANSR, ABRT or a response to a SRVC (TRACE) message. The purpose of the SENT message is to provide a new time to be added to the integrated INTG record in LOGGA. When the record is also augmented with the time the INTG is received from the user, (as recommended in the previous paragraph) it becomes possible to compute turn-around time

for an interrogation as experienced by a user. The data to be included in the SENT message would be the usual header data, the same reference ID as in the ANSR message and the time the transmission to the user began and ended.

(U) The third change to the message format would be the addition of two fields to indicate the size of the queues at the time a message is queued for transmission. The first field would indicate the number of messages ahead of the subject message in terms of priority and precedence. The second field would indicate the number of messages behind the subject in the queue.

(U) Another change would be a new field to be used to identify messages that are a part of an integrated test of the system. Such a field would simplify subsequent analysis of the LOGGA and MTARA data.

3.2.2 Changes to the LOGGA File (U)

(U) The recommended changes to the LOGGA File are closely related to the changes recommended to the various message types. The primary change is the addition of new fields to the file records:

- 1) User input time
- 2) Time user received reply
- 3) Size of queue - higher priority
- 4) Size of queue - lower priority
- 5) System Test indicator

(U) The second change to the LOGGA File is the new message type (SENT) which was discussed in section 3.2.1.

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(U) The third change to the LOGGA is the purging of the DIA to DIA traffic from the file at the time of the cutover to ANSRS. This action will provide compatible data for summarizing COINS file utilization data from the inception of COINS.

(U) Although it is not a recommendation, Informatics believes that it would be interesting to compare the utilization of COINS-type files by the host organization with that of the COINS Community. Historical data collected to date cannot provide this information.

3.2.3 Additional Analyses to be Made (U)

(C) The semi-annual COINS report contained several tabulations of the COINS activity. One tabulation was similar to part 1 of the LOGAR report format. The column headings were October, November, December and Total. The row headings were Aborts, Answers, Interrogations, Releases, and Service Messages. This is a useful report and should be continued. It would be useful if it also contained percentages.

(C) Two other tabulations counted the interrogations, replies and non-replies by requesting agencies and by addressee agencies. These two tabulations should be continued.

(C) A final tabulation was by file and sponsoring agency. It counted the number of interrogations, answers, aborts and non-replies for each month in the quarter. This tabulation provides the data to determine the file's usefulness to the COINS community.

(C) During the course of the study, the Study Team has been asked if the system could provide data to answer such questions as:

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- (C) 1) Are the 2400 baud lines adequate for COINS?
 2) What is the reliability of COINS communications system?
 3) What is the average length for a COINS message?
 4) What is the effect of using standard-length segments?
 5) What is the effect of the current segmenting algorithm?
 6) Do certain files require a longer turn-around time than others? Can the time be predicted?

(C) The answers to the first two questions cannot be determined from the statistics now being collected. Other sources are required. As to the length of COINS message; Table 3-1, Figure 3-6 and Figure 3-7 provide data summarized from the LOGGA File for February 1970. Table 3-1 is a tabulation of message counts by message type and by the number of segments per message. The line identified as blank are DIA-originated messages which were exactly one segment long. The messages that are greater than 100 segments (which is the COINS maximum) are DIA answers being sent to DIA users. Figures 3-6 and 3-7 are bar-charts illustrating the data of Table 3-1 reduced to percentages. Based upon these tables, we can easily say that during February 1970, the average COINS message was 3.6 segments or 554 characters in length. We can also say that 85% of the messages are only one segment long.

(C) Table 3-2, Table 3-3, Figure 3-8 and Figure 3-9 illustrate another type of analysis that might prove to be useful in predicting system response. Table 3-2 contains data extracted from the LOGGA File for nine consecutive interrogations against the LOGGA file. These interrogations were transmitted from NSA to DIA on 14 November 1969. Table 3-3 contains data extracted from the LOGGA File for nine consecutive interrogations against the LOGGA File. These interrogations were input at DIA on 13 March 1970. Figure 3-8

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TABLE 3-1. COINS MESSAGE LENGTH (Page 1 of 5)
BY MESSAGE TYPE (U)

February 1970

Number of Segments Per Message	Total Number of Segments	Number of Messages by Type					
		All-Types	Abort	Answer	Interrogation	Release	Service
blank	3395	3395	219	47	1672	1457	0
1	9433	9433	211	142	1103	1088	6889
2	1150	575	107	289	153	1	25
3	819	273	10	243	19	0	1
4	1108	277	24	253	0	0	0
5	510	102	3	99	0	0	0
6	606	101	0	101	0	0	0
7	525	75	1	73	0	0	1
8	360	45	1	43	0	0	1
9	405	45	0	45	0	0	0
10	190	19	0	19			
11	341	31		31			
12	636	53		53			
13	572	44		44			
14	1512	108		108			
15	285	19		19			
16	400	25		25			
17	527	31		31			
18	322	18	1	17			
19	266	14		14			
20	200	10		10			
21	252	12		12			
22	396	18		18			
23	368	16		16			
24	144	6		6			
25	175	7		7			
26	338	13		13			

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TABLE 3-1. COINS MESSAGE LENGTH (Page 2 of 5)
BY MESSAGE TYPE (U)

February 1970

Number of Segments Per Message	Total Number of Segments	Number of Messages by Type					
		All-Types	Abort	Answer	Interrogation	Release	Service
27	162	6		6			
28	364	13		13			
29	261	9		9			
30	270	9		9			
31	186	6		6			
32	128	4		4			
33	297	9		9			
34	204	6		6			
35	210	6		6			
36	684	19		19			
37	222	6		6			
38	152	4		4			
39	195	5		5			
40	40	1		1			
41	123	3		3			
42	756	18		18			
43	473	11		11			
44	132	3		3			
45	45	1		1			
46	92	2		2			
47	517	11		11			
48	240	5		5			
49	245	5		5			
50	0	0		0			
51	102	2		2			
52	104	2		2			
53	583	11		11			

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TABLE 3-1. COINS MESSAGE LENGTH (Page 3 of 5)
BY MESSAGE TYPE (U)

February 1970

Number of Segments Per Message	Total Number of Segments	Number of Messages by Type					
		All-Types	Abort	Answer	Interrogation	Release	Service
54	108	2		2			
55	220	4		4			
56	504	9		9			
57	114	2		2			
58	348	6		6			
59	1593	27		27			
60	300	5		5			
62	124	2		2			
63	126	2		2			
64	64	1		1			
65	130	2		2			
66	264	4		4			
67	134	2		2			
68	272	4		4			
69	276	4		4			
70	210	3		3			
71	213	3		3			
72	288	4		4			
74	74	1		1			
75	225	3		3			
76	228	3		3			
77	77	1		1			
78	78	1		1			
79	79	1		1			
81	162	2		2			
82	82	1		1			
83	249	3		3			

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TABLE 3-1. COINS MESSAGE LENGTH (Page 4 of 5)
BY MESSAGE TYPE (U)

February 1970

Number of Segments Per Message	Total Number of Segments	Number of Messages by Type					
		All-Types	Abort	Answer	Interrogation	Release	Service
84	336	4		4			
85	225	3		3			
86	172	2		2			
89	89	1		1			
95	190	2		2			
96	96	1		1			
97	291	3		3			
100	4800	48		48			
102	102	1		1			
104	104	1		1			
106	106	1		1			
108	108	1		1			
117	117	1		1			
123	123	1		1			
132	132	1		1			
139	139	1		1			
153	153	1		1			
157	157	1		1			
176	176	1		1			
178	178	1		1			
201	201	1		1			
204	204	1		1			
223	223	1		1			
233	233	1		1			
251	251	1		1			
255	255	1		1			
259	259	1		1			

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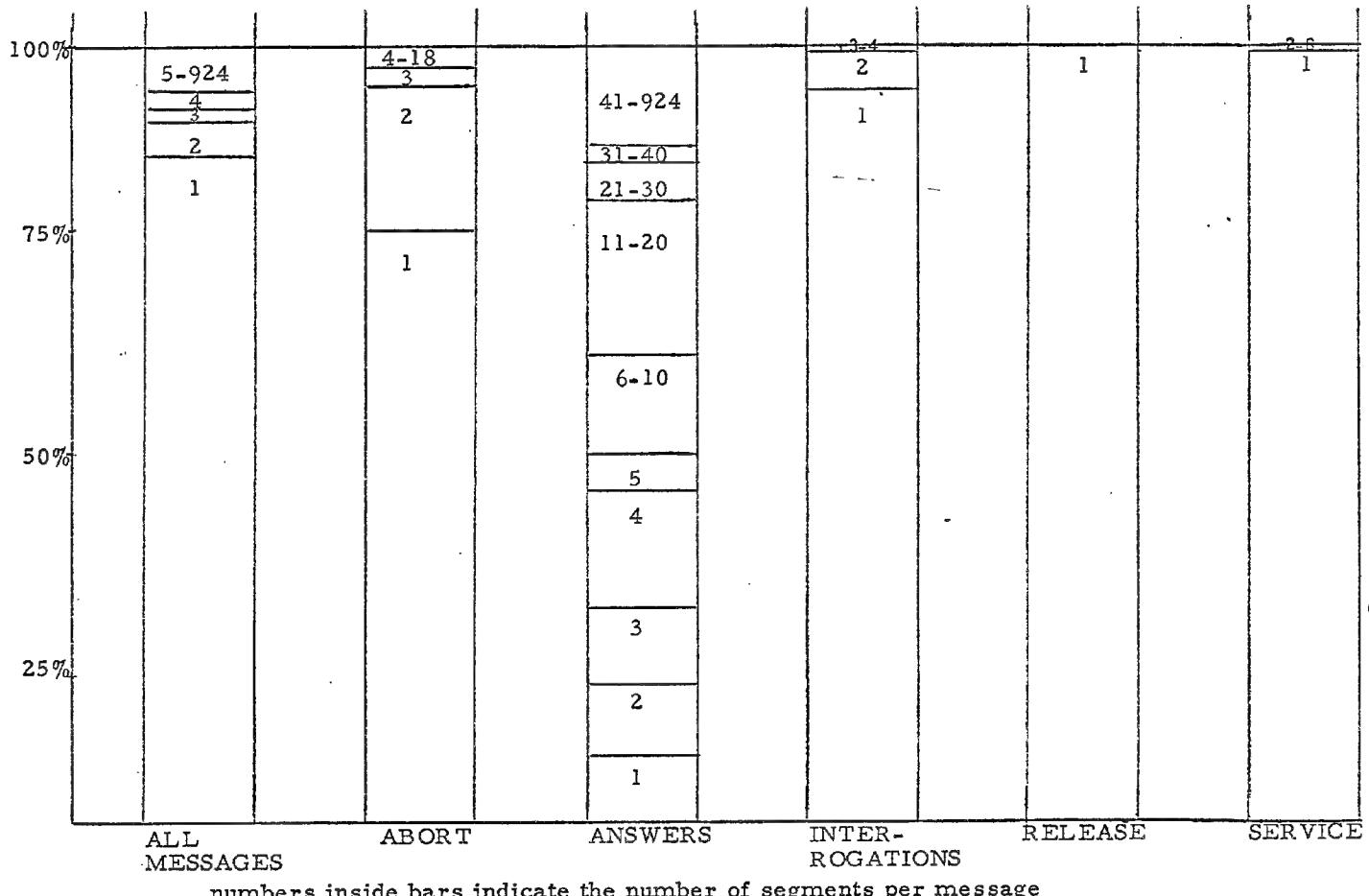
(C) TABLE 3-1. COINS MESSAGE LENGTH (Page 5 of 5)
BY MESSAGE TYPE (U)

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Number of Segments Per Message	Total Number of Segments	Number of Messages by Type					
		All-Types	Abort	Answers	Interrogation	Release	Service
276	276	1		1			
283	566	2		2			
324	324	1		1			
332	332	1		1			
405	405	1		1			
411	411	1		1			
547	547	1		1			
557	557	1		1			
644	644	1		1			
675	675	1		1			
796	796	1		1			
924	924	1		1			
Total	54441	15140	577	2153	2947	2546	6917

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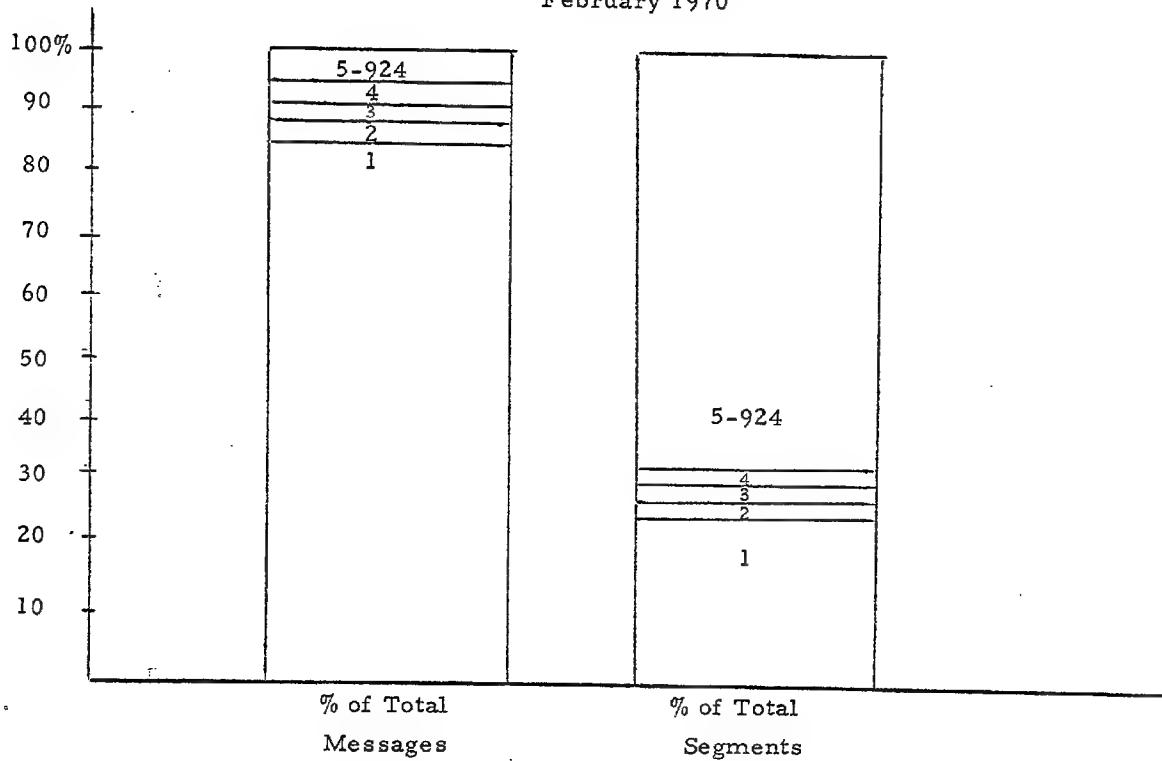
(C) Figure 3-6. Analysis of COINS Message Length By Message Type
February 1970 (U)



(C)

Figure 3-7. Comparison of Percentages of Total COINS Messages
and Total Segments by Segment Length/Message (U)

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(C)

Table 3-2. Time Analysis of Nine Consecutive INTGs Against LOGGA File
on 14 November 1969 (U)

	INTG & Reply	INTG ABRT (F) (1)	INTG ABRT (F) (2)	INTG ANSR (3)	INTG ANSR (4)	INTG ANSR (5)	INTG ABRT (F) (6)	INTG ANSR (7)	INTG ANSR (8)	INTG ANSR (9)
Time Message Entered Switch	TIMEX	14:130	14:161	14:319	14:386	14:448	14:519	14:569	14:760	14:840
Time RCPT Sent/Received	RCPTM	14:131	14:167	14:320	14:386	14:448	14:519	14:570	14:760	14:840
Time Message Queued for Transmission	SWIRE	14:131	14:167	14:320	14:386	14:448	14:519	14:570	14:760	14:840
Time RCPT Received on Relayed Message	RCPRE	blank	blank	blank	blank	blank	blank	blank	blank	blank
Time INTG Queued for Edit (blank for ADDRE ≠ DIA)	QETIM	14:131	14:167	14:320	14:386	14:448	14:519	14:570	14:760	14:840
Time Last Segment Received from HOST for ANSR or ABRT	FIFTY	blank	blank	blank	blank	blank	blank	blank	blank	blank
Time INTG Received at Switch	TIME 2	blank*	blank*	14:321	14:388	14:450	14:521	14:571	14:763	14:841
Time Reply Received at Switch	TIME 3	blank*	blank*	14:399	14:465	14:604	14:686	14:725	15:010	15:178
Time Reply Queued to Leave Switch	TIME 4	14:132	14:168	14:400	14:466	14:607	14:687	14:728	15:014	15:183
Length of Interrogation	LNGHI	1	1	1	1	1	1	1	1	1
Length of Reply	LNGHA	2	2	2	2	9	1	9	14	14
Elapsed Time	(TIME 4 - TIMEX)	:002	:007	:081	:080	:159	:168	:159	:254	:343

* Fault detected by 360-30 rather than 360-50

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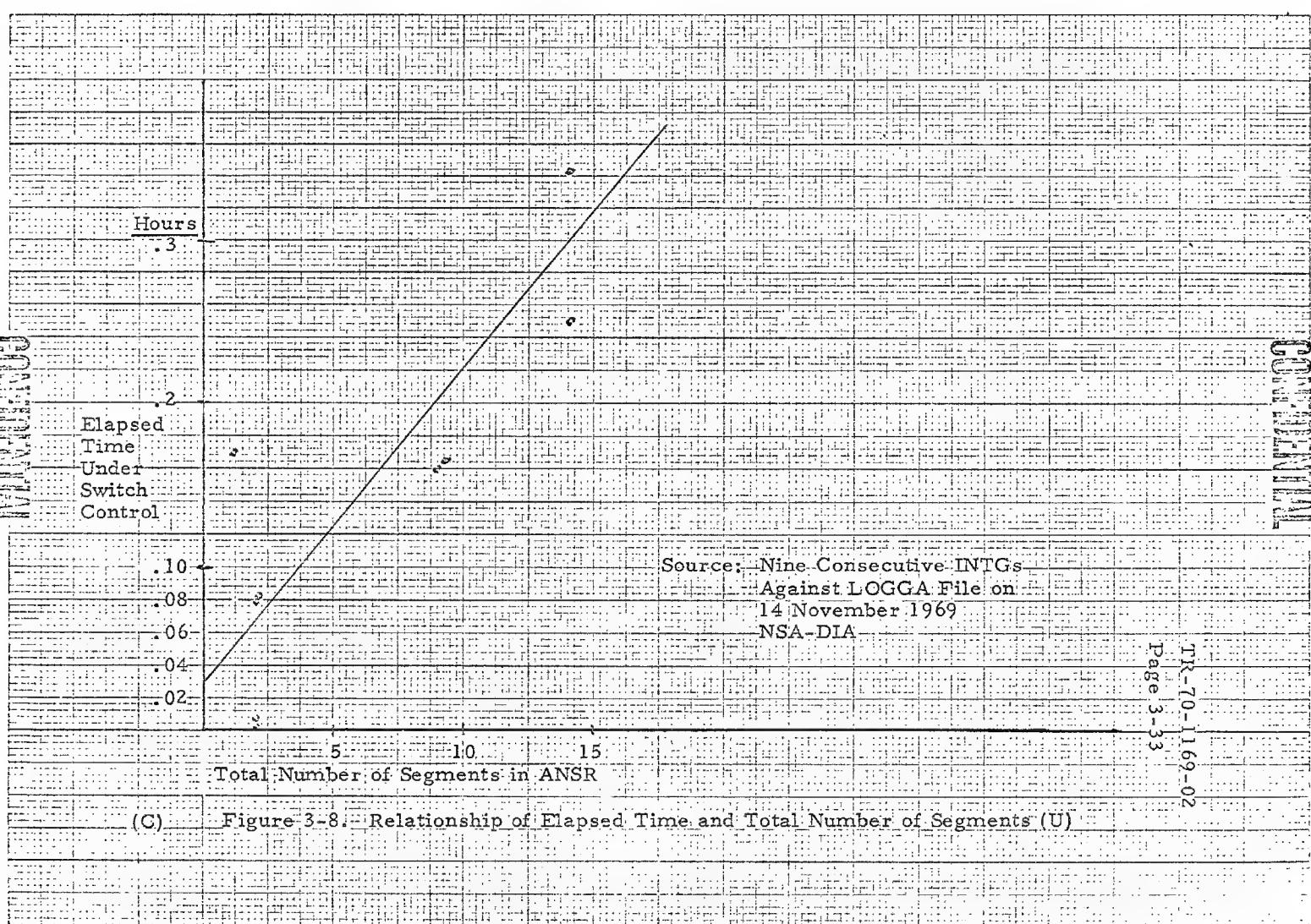
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(C)

Table 3-3. Time Analysis of Nine Consecutive
INTGs Against LOGGA File on 13 March 1970 (U)

Number	LNGHI	LNGHA	INTG TIMEX	Type Response	Time Response	Elapsed Time
1	0	0	08.701	FAULT ABRT	08.728	.021
2	0	2	08.840	ANSR	08.945	.105
3	0	6	00.965	ANSR	09.070	.105
4	0	6	09.482	ANSR	09.682	.200
5	0	1	09.535	ABRT FAULT	09.687	.152
6	0	1	09.604	ABRT FAULT	09.691	.091
7	0	5	09.663	ANSR	10.092	.429
8	0	4	11.935	ANSR	12.138	.203
9	0	4	11.995	ANSR	12.241	.246

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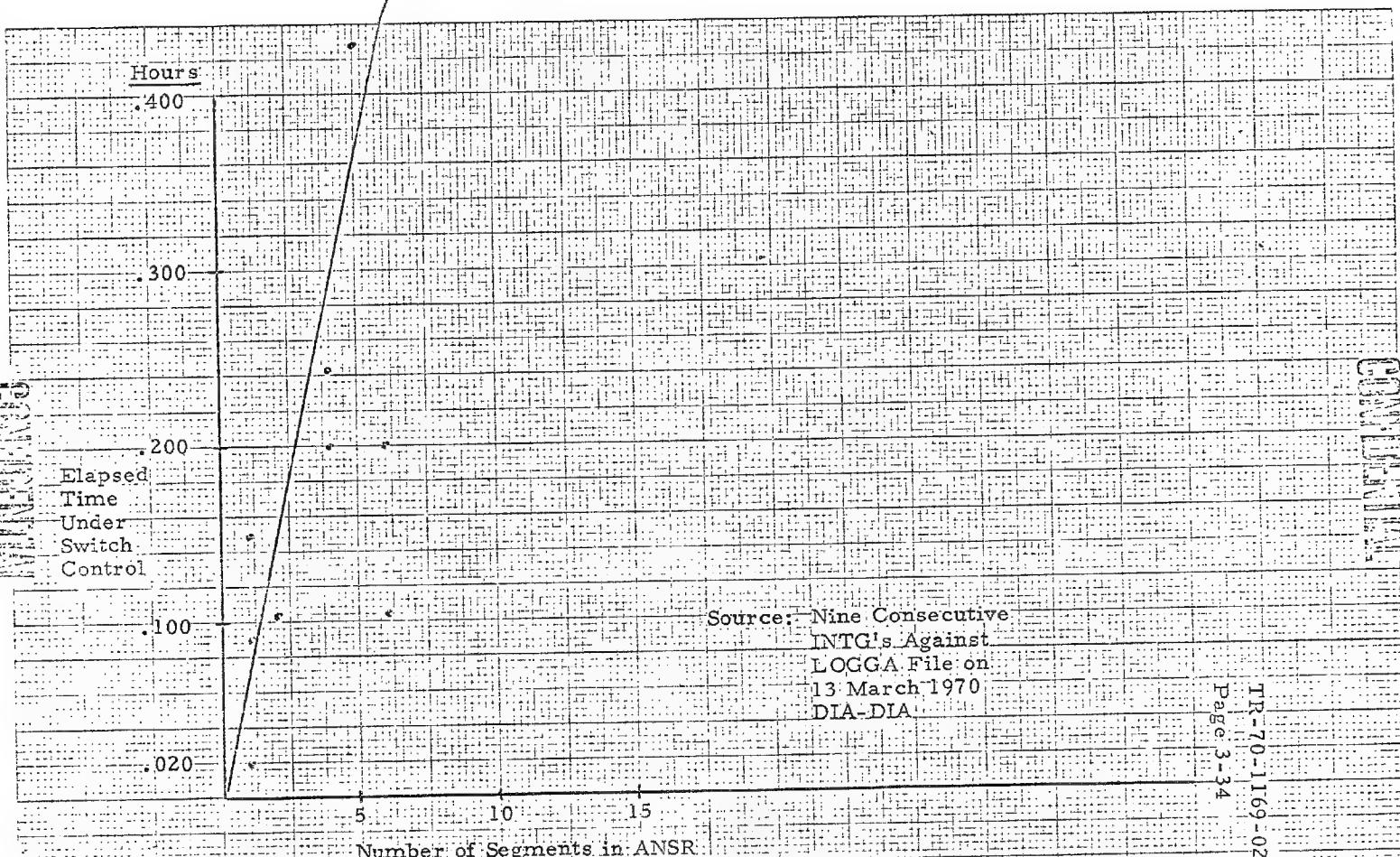


Figure 3-9. Relationship of Elapsed Time and Total Number of Segments (U)

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is a scatter diagram of the data for Table 3-2. The straight line is an approximate least squares fit. It appears that there is some correlation between the turn-around time and size of the ANSR message. Figure 3-9 is a scatter diagram for the March 1970 data. These data do not evidence any high degree of correlation.

(C) Because of the contradictory results shown in Figures 3-8 and 3-9, it is recommended that a computer program be developed that would summarize the data necessary for a more comprehensive analysis and could compute least square lines and correlation coefficients for each file and calendar month under study.

(U) The addition of the counts of messages in the queues to the LOGGA can provide some necessary data for estimating communications loads. Peak periods can be identified by sorting on these two fields. Message and segment counts by hours and by agencies can be expected to provide an estimate of communications load during peak periods and during normal periods. The team would be required to estimate the additional load imposed by re-transmission due to parity errors.

(U) The computation of turn-around time from the user point-of-view can be computed from the two new time fields that have been recommended for inclusion in the LOGGA File. From these fields, a more comprehensive measure of system response time will be available and can be summarized by agency and by file. It should be noted that interrogations that fail to be received by the switch still continue to be omitted from the LOGGA File.

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3.3 ESTIMATED COSTS (U)

(C) The estimated costs for these recommendations is as follows:

<u>Recommendation</u>	<u>Cost</u>
1. Add User Time to Header record.	3 man-months for Switch and for each system
2. Add User Input Time to Network Activity Log	2 man-months for Switch
3. Add SENT message-type to Switch and system programs	3 man-months for Switch and for each system
4. Add SENT message-type to Network Activity Log	2 man-months for Switch
5. Add the two queue counts to the various message formats	3 man-months for Switch and for each system
6. Add the two queue counts to the Network Activity Log	2 man-months for Switch
7. Add System Test Indicator to the various message types	one man-month for Switch and 3 man-months for each system
8. Add System Test Indicator to Network Activity Log	one man-month for Switch
9. Add the five new fields to LOGGA File	4 man-months for Switch
10. Add the five new fields to the MTARA File	one man-month for Switch
11. Add the SENT message type to the LOGGA file	one man-month for Switch (plus one man-month to change LOGAR RIT)
12. Add the SENT message type to the MTARA file	one man-month for Switch
13. Delete DIA-to-DIA traffic from LOGGA file	2 man-months for Switch
14. Prepare RIT to tabulate messages by message type and message length and to compute needed percentages	2 man-months

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(C)	<u>Recommendation</u>	<u>Cost</u>
15.	Prepare RIT to compute selected least square lines and related correlation coefficients	5 man-months
16.	Prepare RIT to tabulate and plot queue sizes based on several groupings and selection criteria, (such as by hour, day of week, agency, file, etc.)	3 man-months
17.	Prepare RIT to compute average turn-around time by file and agency based on two new user times	3 man-months

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SECTION 4

COINS COMMUNICATIONS (U)

4.1 GENERAL (U)

(U) In the preliminary report, a brief discussion of COINS computer configurations was included. This section of the final report will deal with the subject in more detail. However, because of the complexity of this area, the discussion in this section will be limited to the methodology involved in choosing possible alternative configurations and a rationale for the performance of this work.

(U) This section of the report includes a discussion of future techniques in data communications, the need for studying alternative COINS communications configurations and an outline of the methodology to perform this study in the future. The questions that should be answered during this investigation are:

1. Is there, or will there be a need in the future to upgrade the capability of the COINS communications subsystem?
2. What new products or techniques could cause the community to redesign the COINS communications subsystem?
3. What operational considerations have the most effect on the design of the COINS communications subsystem?

(U) The COINS switch is considered part of the COINS communications subsystem. The communications subsystem encompasses a great deal more than the COINS switch. It includes the data communications modems, lines, communications controllers, interface computers and interface software. This section of the report discusses possible changes to the COINS communications subsystem in light of:

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- Changing requirements
- New products or techniques

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4.2 REQUIREMENTS (U)

(U) There are four basic areas which must be considered as effecting the design of a future COINS Communications Subsystem. These are:

1. The capacity of the communications subsystem in terms of data throughput.
2. The reliability of the communications subsystem.
3. The ease with which nodes can be added or deleted from the system.
4. The integrity of the data in a multi-level security operation.

(U) These subjects are discussed in this section. It is intended that this discussion provide the basis for further work in this area. It is not anticipated that this section will contain a complete discussion of the requirements for the COINS Communications Subsystem. The four topics are basic to any changes to COINS and must be formalized before a more detailed study can begin.

4.2.1 System Capacity (U)

(C) The communications backbone of COINS is centered around the three 2400 baud full duplex lines which connect the switch at DIA with the other three participating agencies. The total throughput rate of the switch is therefore limited to 1800 characters per second. This was arrived at by figuring that 2400 baud is equivalent to 300 characters per second and that each line operates in a full duplex mode. The model 1850 Channel to Channel Adapter between the Switch and the 360/50 computer at DIA has not been taken into consideration. This device is capable of transmitting data at a rate in excess of 150,000 characters/second. At this time, the community is hard pressed to utilize this data capacity to its fullest. During an

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average day there are approximately 150 to 160 interrogations which generate an average of 1260 characters for each answer for a total of 472,000 characters/day (all message types). This is less than 5% of the system communications capacity. All of the other messages which are transmitted by the switch are in fact to expedite the flow of interrogations and answers. The community therefore has purchased a communications capacity equal to 20 times its present utilization. The 360/30 computer is capable of handling data at a rate in excess of the current communications capacity. A more detailed analysis of the switch software would be required in order to determine when the computer itself would be saturated. It does seem likely however that the COINS switch could handle any load which might occur in the near future.

(C) As COINS progresses from an experiment to a fully operational system, the question of switch capacity will become more critical. Since DIA is using a 360/30 computer, all that is necessary to increase the switch capacity is to purchase a larger model of the computer. The programs which currently operate on a 360/30 are upward compatible with the rest of the 360 product line. In order to increase the communications line capacity, it is only necessary either to increase the speed of the line or add more lines.

(U) If the central switching computer is eliminated, and a switched network is substituted, all that is necessary is that a sufficient number of lines be provided to handle the COINS traffic. This is of course in addition to the modification to the existing user agency software.

4.2.2 Reliability (U)

(U) Presently the COINS Network operates with a 360/30 computer acting as a store and forward switch. This computer

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system is not particularly suited to an operational environment where it must be functioning at all times. There are a number of serious drawbacks with the switch system which include:

(U) In an operational environment, it will be necessary for the switch to be on the air 24 hours per day, 7 days a week. Presently the switch does not have adequate backup to assure that this can be done. There are several ways to insure that the communications between COINS nodes can be maintained despite individual failures. These are:

1. Provide the capability to recover from a disk failure.
2. Provide a backup switch.
3. Use a dial network without a central switch

4.2.2.1 Disk Failure (U). The preliminary report made a recommendation that a serial log tape(s) be added to the 360/30 switch in order to provide a record of all COINS messages. If this recommendation were followed, the following benefits would be gained:

1. The Switch would have a detailed convenient historical record of COINS activity;
2. The Switch would be able to recover from a disk failure;
3. The Switch could guarantee that any messages received for would be delivered to their destinations.

(U) The first benefit would make it easier to gather information about the "experiment". This information might not be required in an operational environment but is necessary when developing modelling criteria or evaluating system performance.

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(U) The Switch is currently unable to recover from a disk failure. If a log tape were added to the system, it would be used to reconstruct the queue files so that operations could continue after a failure. The information to be journalled on tape should include:

1. A copy of the input message;
2. An identifier for the message;
3. A record indicating that the input message was transmitted;
4. Checkpoint records.

(U) After the disk failure is repaired, the journal tape would be searched to find the last checkpoint record. The checkpoint record identifies all messages which have not been completely processed by the switch. These are placed in the queue file but will be removed if a transmittal record for the message is found. This process should completely rebuild the disk queue files.

(U) Presently the Switch can lose messages for which it has generated a receipt if a computer failure occurs between the time the message was received and a checkpoint. The use of a journal tape would eliminate this situation by identifying all messages the Switch receives and transmits.

(U) The use of a journal tape may cause a message to be retransmitted if a failure occurs between the time a message was transmitted and the time the transmission was logged. This is a minor problem which can be corrected by software at each of the agencies.

4.2.2.2 Backup Switch (U). It is possible to provide a backup switch for the 360/30 computer. This has been proposed in the past

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and would require a redundancy of equipments. An additional 360/30 switch would be required which contained the same hardware features as on the switch computer and which could be programmed to receive data from the switch while it was operating. This data would be in the form of packets which contained enough information to identify the location of all messages being transmitted by the switch, their disposition, and the state of the switch. In the event of a switch failure, the backup computer would take control of the switching function and continue the distribution of messages.

(U) What is required is that a backup switch have access to the same peripheral devices that the switch computer does and that an efficient means of transmitting operational recording information be found. The major drawback to the use of a backup switch is the cost involved. The backup switch performs only background tasks until the time it is required to handle the distribution of messages.

4.2.2.3 Switched Network (U). If the COINS network were switched in nature, it would be possible for any of the nodes to communicate with one another by dialing up the desired system. The software required for this change is not too extensive and the major drawbacks seems to be that of synchronizing cryptographic gear. If there were some way to assure that the lines could be secure, then a switched network seems to be a good possibility for future COINS improvement. Switched lines are available for speeds from 75 baud up to the rates for the T1 carrier system. It is possible to transmit large quantities of data over switched lines if the switching equipment is quiet. There are four main types of switching methods currently in use in the telephone network. These are:

1. The electronic switching system (ESS)
2. Cross bar switches
3. Panel switches
4. Rotary switches.

(U) ESS is the most up to date switching method in use today. ESS will not replace all other switching methods for at least another 30 years. Instead ESS is being used for new offices and for the gradual replacement of old equipment. This replacement schedule is determined by the Bell System supply of man power, equipment, and money, and is effected by government specified depreciation policies. Data communications is adversely affected by the use of rotary and panel switches. These are noisy and are not particularly efficient. The use of data communications with computers will probably speed up the replacement of these types of switching systems. It should be kept in mind that rotary and panel switching systems are noisy and that any data communications should be designed to avoid these type of switches. COINS should utilize either an electronic switching method or a cross bar type of switch.

(U) A recent development that could be of interest to COINS is the introduction of broadband switching. The Western Union Telegraph Company has placed into operation the first switching center of a public broadband network. In its initial phase, it serves only a small number of cities in the United States, but it will no doubt grow into a nationwide service. An interesting feature of the system is that the user can select the amount of bandwidth desired in the channel. That is, if the user has a requirement for a 48 kc channel, when he dials the number he also dials in the fact that a 48 kc channel is required. When the connection is made, the channel is capable of handling this data rate. The Western Union system is capable of handling 2 kc, 4 kc, 8 kc, 16 kc and 48 kc

channels. Presently only 2 and 4 kc channels are available. The Western Union circuits for this system will all be four wire and will be appropriately equalized at all switching points. This will lessen echo problems and gives a return path for error correction and control functions on the data handling machines. The T1 carrier system can be switched. Presently this service is available on a point-to-point basis only. However, there is no reason why a PCM system cannot be switched. This could be accomplished either through the use of an electro-mechanical switching device or through a computer. For instance, if a computer were used to handle a T1 switch for the COINS community, three T1 circuits might be used. If additional reliability through redundancy were required, additional circuits could be employed. Project Tetrahedron will provide switched voice T1 circuits to the community. This project will be investigated for its applicability to COINS in a latter report.

4.2.3 Modularity (U)

(U) In the future the COINS network will undoubtedly contain more than four nodes. Therefore a major goal of the system is to enable additional participants to be accommodated with ease and without necessitating reprogramming at the individual nodes. Two forms of communications organization lend themselves easily to accommodating additional nodes. These are:

1. A system utilizing a central switch and computer;
2. A system utilizing switched lines.

(U) Any system in which the switching functions are distributed among the individual nodes will require software modification at each of these nodes whenever the network is changed. Regardless of how the software is organized or how simply the

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changes can be made, the fact is that these changes must be made at every node. Therefore any distributed type of software switch does not lend itself to accommodating new users.

(C) In the preliminary report we indicated that the 360/30 switch was rather inflexible since most of core was utilized and that software changes to the switch could not be affected easily. This situation has changed since the DIA internal terminals are being taken off the 360/30 computer and are to be serviced by the GE 635 Time Sharing System. There are approximately 35,000 characters of core which can be utilized to:

1. Upgrade the switch
2. Add new systems to the network.

(U) If the central switching computer were replaced by a switched line network, additions to the network could be handled fairly simply. The systems wishing to utilize COINS files would merely have two format messages in a format compatible with the COINS standard and dial the line associated with the systems on which the files resided. It would be the responsibility of the system whose files were being accessed to verify that the system originating the interrogation could in fact access the file of interest.

4.2.4 Security (U)

(U) Currently the COINS Network operates with one type of compartmented data. In the future it may be necessary to operate with more than one compartmented set of data. It is outside the scope of this work to discuss this problem, however it will have to be resolved in the future. Such a resolution is generally made on an individual basis and the COINS network must be prepared to undergo investigation to determine if mixed data can be transmitted over this same network.

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(U) It will be one of our tasks in the next phase of work to determine if there are any new means of encryption or switch organization which could allow COINS to operate in a multi-level security environment. It appears presently as if a means of encryption and super-encryption can be utilized in a future version of COINS. Hardware features on a central switching computer such as paging and read/write protect might be sufficient to enable a central software switch to operate in this type of environment.

4.3 NEW PRODUCTS AND TECHNIQUES (U)

(U) The direction that the COINS network takes in the future will be primarily dictated by the requirements of the community. It will also be affected by new advances in the state-of-the-art in communications. One of the most exciting new developments in the area of data communications is the use of the T1 pulse code modulation (PCM) system. Although the T1 system has been operational since 1962, it is only recently that the government has become aware of the cost savings associated with the use of this system. T1 also offers improvements in error rate, elimination of expensive modems and compatibility with modern crypto methods.

(U) Another area in which there is sure to be advancement is the area of secure communications. This is inextricably tied to the development of pulse code modulation and time division multiplexing (TDM) systems. Utilizing PCM and TDM, complex secure communications facilities can be developed which allow compartmentation of data as well as a reduction in the number of crypto units required for communications.

(U) These two areas are discussed in this section. Future work on COINS will investigate both areas in more detail.

4.3.1 T1 System (U)

(U) The COINS effort has been underway for a number of years. This is one of the first networks of computers in existence. Originally the decision was made to utilize a central store and forward message switching computer to interface the computer systems at the various agencies. The central store and forward switch has been upgraded to a 360/30 computer. A major question confronting the designers of this system is, "Is the switch powerful

enough to work in a future COINS environment in which the volume of traffic is substantially greater than that experienced today?" The 360/30 computer is in the small to medium scale class and can be easily upgraded to a more powerful computer. In fact the 360/30 computer can be upgraded to a more powerful 360 computer without necessitating any software changes.

(U) COINS has been operating with leased, conditioned lines between the switch and the agency computers. These lines operate at a speed of 2400 baud. These are considered medium to high speed lines. However, recent advances in communications technology show that lines with a greater capacity can be furnished to COINS at either a cost savings or at no appreciable increase in cost. The lines that are currently being used in COINS can with the appropriate modems be used to transfer data at greater speeds than are currently achieved. It is possible to obtain data rates of 9600 bits per second over conditioned leased telephone lines. It is not necessary at this time to increase the capacity of the communications facilities because of the experimental nature of the system. In the future, however, when COINS will be used more as an operational tool, it may be necessary to increase the communication capacity significantly. Up to this time this increase in capacity has been costly in terms of equipment. Conditioned leased lines are basically analog in nature and the modems required to convert analog signals to digital and vice versa are costly.

(U) The Bell System has introduced the T1 carrier which is the first commercial digital communications facility. This system is capable of carrying 1.544 million bits per second in each direction and can handle 24 phone conversations simultaneously. Since the network is basically digital in nature, costly modems are not required. Similarly because of the digital nature of the system, regenerators need only determine that a pulse is a one or a zero.

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and must not be extremely sensitive to its amplitude, thus regenerators sell for approximately \$250 a piece and are used every 5000 to 6000 feet along the line. The T1 system can operate successfully in a signal to voice environment as severe as 12 db. An analog telephone transmission system requires an overall system signal to noise ratio of 60 db. The Bell system claims that the error rate is less than 1 per 10 million bits transmitted, although in actual practice this figure is significantly less.

(U) Presently, the telephone industry utilizes frequency division multiplexing methods for channel definition. There is a basic four kilocycle allocation for a voice channel. Groups of channels consist of 12 voice channels, super groups are 5 groups and master groups are 10 super groups. Groups are created by techniques very similar to those employed in radio broadcasting. Different carrier frequencies are used for the different voice channel members of a group. This technique is called single side band suppressed carrier transmission. At the receiving end, the voice channel signals are recovered by techniques similar to those used in radio receivers. Since the data we are concerned with is carried over telephone lines, it is subject to the tariffs imposed by the communications industry and to the engineering problems associated with creating digital data in an analog medium. The T1 system is basically digital in nature and has not been tariffed by AT&T, therefore it lends economy of operation, simplicity of engineering, and reliability to COINS.

(U) The telephone system will be basically digital in the future. Under PCM techniques, voice signals would be transmitted from the originating telephone to a local central office by way of a two wire subscriber loop. This is still an analog system. The current telephone system operates in this manner. At the local central office, the amplitude of these signals would be measured

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8,000 times per second to the nearest of 128 different amplitude levels. Seven bits represent each of these measurements; an additional bit is added for signalling purposes (to determine the line is in use etc.) to create an 8 bit group. These groups are then transmitted to the destination local central office. At the destination local central office, these 8 bit groups are used to create continuous electrical signals that closely approximate the original voice signals; they also control the necessary signalling. The receiving party hears the voice of the originating party with all of its individual characteristics even through the message was transmitted as a series of binary groups.

(U) The pulse code modulation techniques lend themselves to time division multiplexing to transmit many conversations at the same time. Time division multiplexing is accomplished by scanning 24 voice conversations in sequence and transmitting the 8 bit groups representing the different conversations as a transmission frame. An extra bit is thrown into the frame for control (on or off loop), thus 193 bits are sent as a transmission frame. A PCM system utilizing time division multiplexing techniques is ideal for the transmission of data. Most data communications are in the form of 8 bit bytes and such compatibility would be excellent for PCM and time division multiplexing.

(U) There is one problem in attempting to get the maximum 1.544 million bits per second over a T1 carrier. This is the fact that data must be sent synchronously to achieve this rate. Very few terminals are equipped to handle this data rate and it seems likely that synchronization errors could occur. Bell telephone has developed a system for transmitting asynchronously over the T1 carrier system. This causes a great reduction in the maximum number of bits which can be sent in this manner. In order to transmit data asynchronously over the T1 carrier system, a unique

system of transitional coding is used. This enables the T1 carrier system to transmit asynchronous data at any bit rate up to the maximum. For every data bit transmitted in this manner, two additional bits are sent to define:

1. A transitional state
2. The state of the data itself.

(U) The maximum asynchronous date rate which can be sent over one T1 carrier system is therefore 512,000 bits per second. This may be subdivided into channels of any size for the users particular needs. Some standard off the shelf multiplexer units enable a user to have:

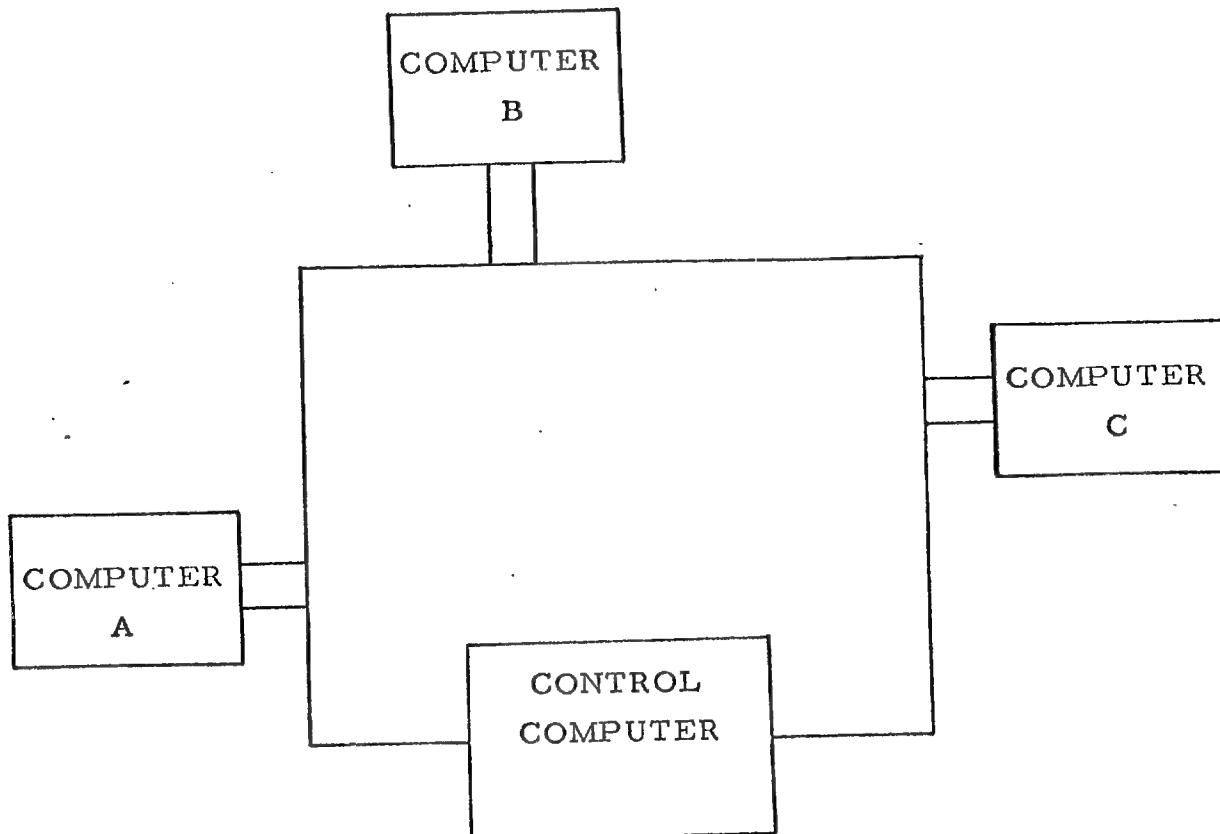
1. 8 channels with 0 to 64,000 bit per second
2. 4 channels with 0 to 64,000 bit per second and 1 channel with 0 to 256,000 bit per second
3. 2 channels with 0 to 256,000 bit per second
4. 1 channel with 0 to 512,000 bit per second

(U) These terminal devices are sold at prices that are comparable to 4800 baud modems. Many users today are unprepared to use this type of capability. The software technology is aimed primarily at circuits with teletype speeds, and any system utilizing large numbers of high speed circuits must be very carefully designed.

(U) The T1 system must give up two thirds of its bandwidth in order to operate asynchronously. For situations using networks of computers, this might not be necessary. Figure 4-1 shows a system which could be used with computers and made to operate at a speed approaching its rated capacity. Basically this system is a conveyor belt type of system with one computer controlling the transmission on the T1 carrier system. Data would be transmitted

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(U)



T1 Line (simplex)

Data is transmitted in 193 bit frames. Eight bits are used for "framing". "N" bits are used to identify routing. (N equals the number of terminals on the loop). N should be a multiple of 8 in order to transmit on a "byte" basis.

FIGURE 4-1. T1 Synchronous System (U)

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in blocks of 193 bits consistent with a "frame of voice data." The first three "bytes" of data could be used to define the control information for each segment. In this manner approximately 85% of the bit stream could be used for data. A synchronization error would result in a frame being retransmitted. If the control information were properly defined, the synchronizing error would be detected easily. If the stations on the loop (conveyor belt) are computers, the data in the frames can be further analyzed and transmitted to other users. These computers in turn could control their own T1 loop for use by the same or other computers.

(U) The 360/65 and the Univac 494 computers can terminate a number of T1 carrier systems without affecting their normal processing functions. It would seem that a system could be built for COINS utilizing two full duplex T1 carrier systems. Figure 4-2 shows this configuration. This is an advanced system which is capable of handling over 3 million bits/second in each direction. The beauty of this approach is that 3 bit transitional coding would not be necessary.

(U) The T1 carrier systems uses a good grade of regular cable with two wire pairs per T1 channel. Since this is the normal type of equipment used in the telephone system, it is possible to switch channels in a system. A switched system would enable users at any of the agencies to dial another agency to provide a data path. It might be possible to request a certain size channel (in multiples of a basic channel allocation) when the connection was established. A switched T1 system would provide more capability than can be currently used in COINS. Therefore it would be desirable to utilize some of the T1 channels for voice as well as data transmission.

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4.3.2 Secure Communications (U)

(C) Since the T1 system is basically digital in nature, and channels can be assigned using time division multiplexing techniques, one unit can be utilized to encrypt the whole data stream. At the other end of the line, a single unit can be used to present the clear text. Figure 4-3 shows how these units might be arranged.

In a multi-level security environment, it would be necessary to super-encrypt certain communications channels to prevent the data from appearing in clear text to other compartments. Figure 4-4 shows this arrangement of channels and crypto units.

(C) In a switched T1 system, certain channels can be reserved for super encrypted data. These channels would be unavailable to the rest of users of the communication network. A future area of study is to determine whether super encryption is feasible in a switched network without reserving pre-specified channels. If this is feasible, then COINS can efficiently utilize communications services provided the entire community.

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(C)

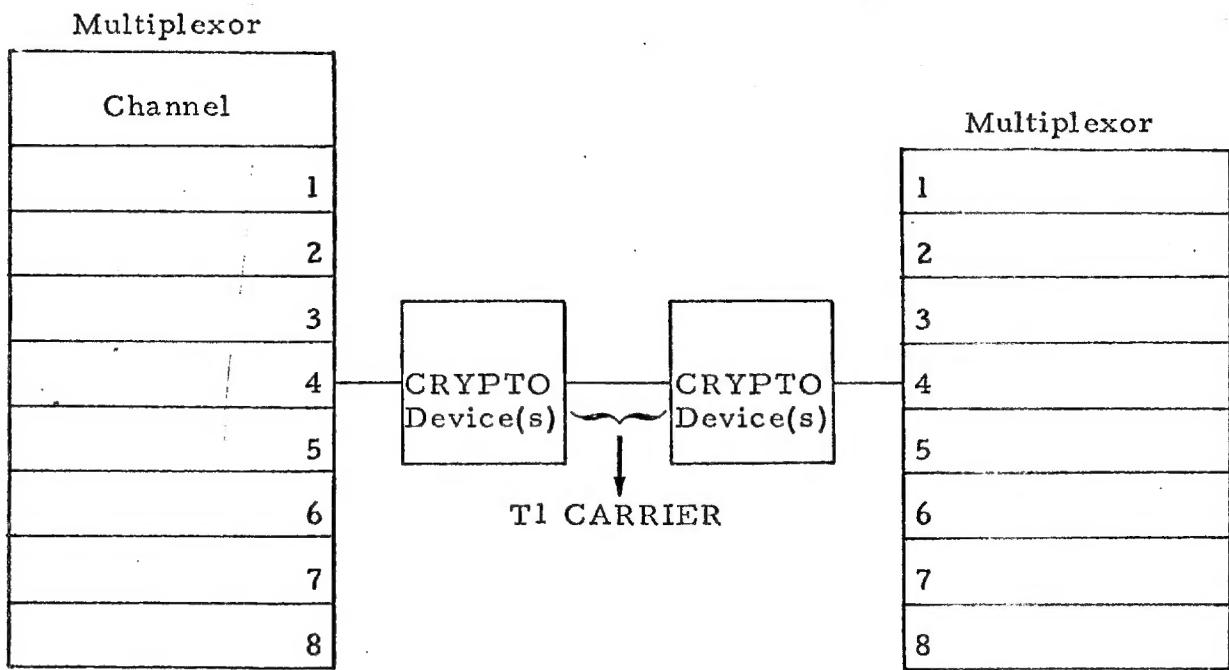


FIGURE 4-3. Secure T1 System (U)

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(C)

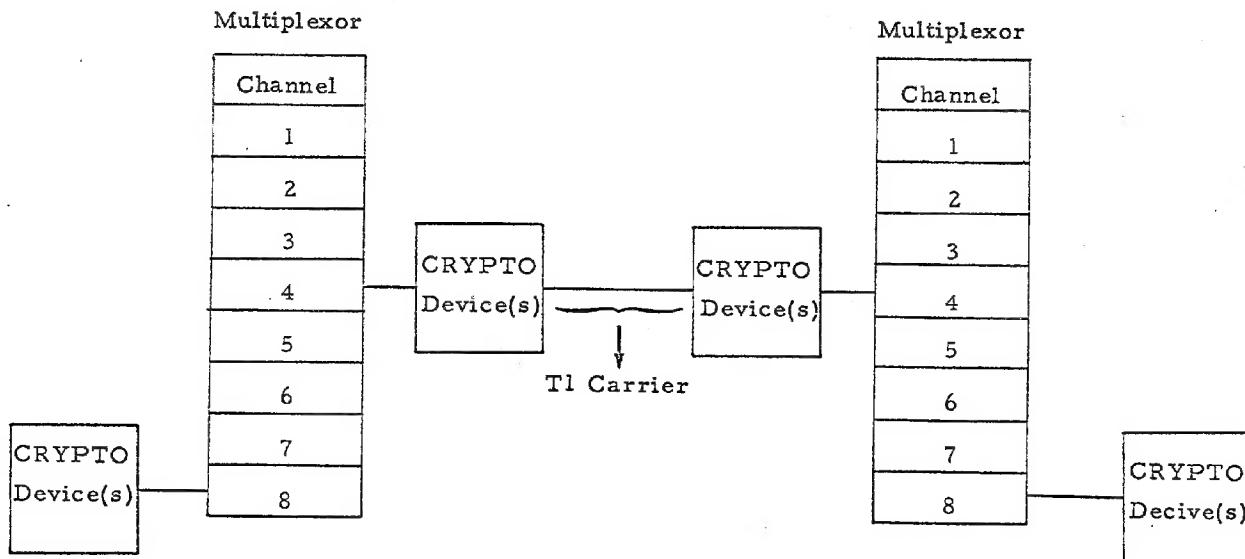


FIGURE 4-4. Super Encrypted T1 System (U)

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